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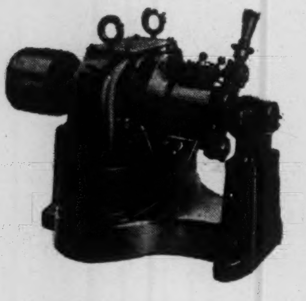

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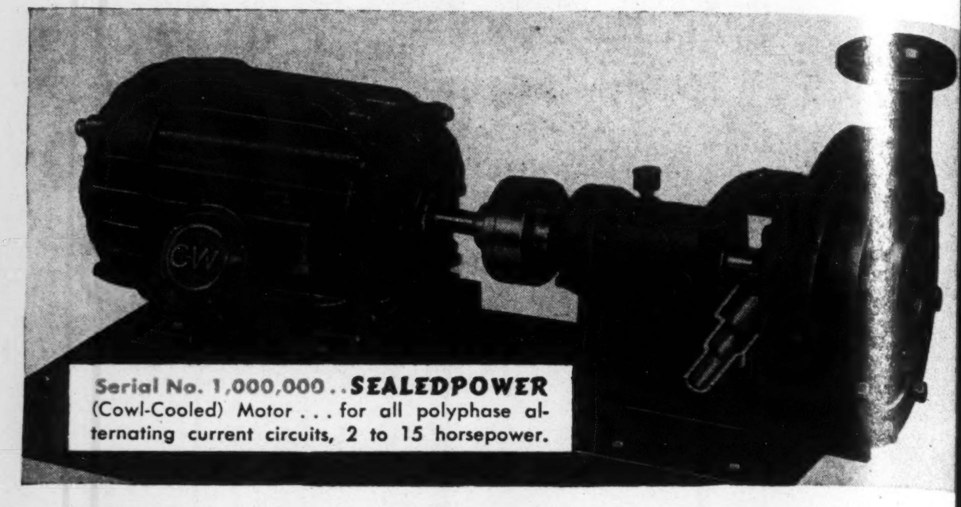

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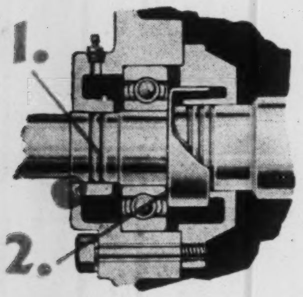

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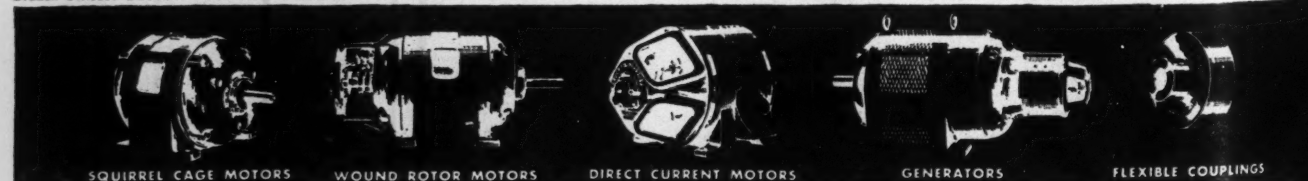

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Centralized
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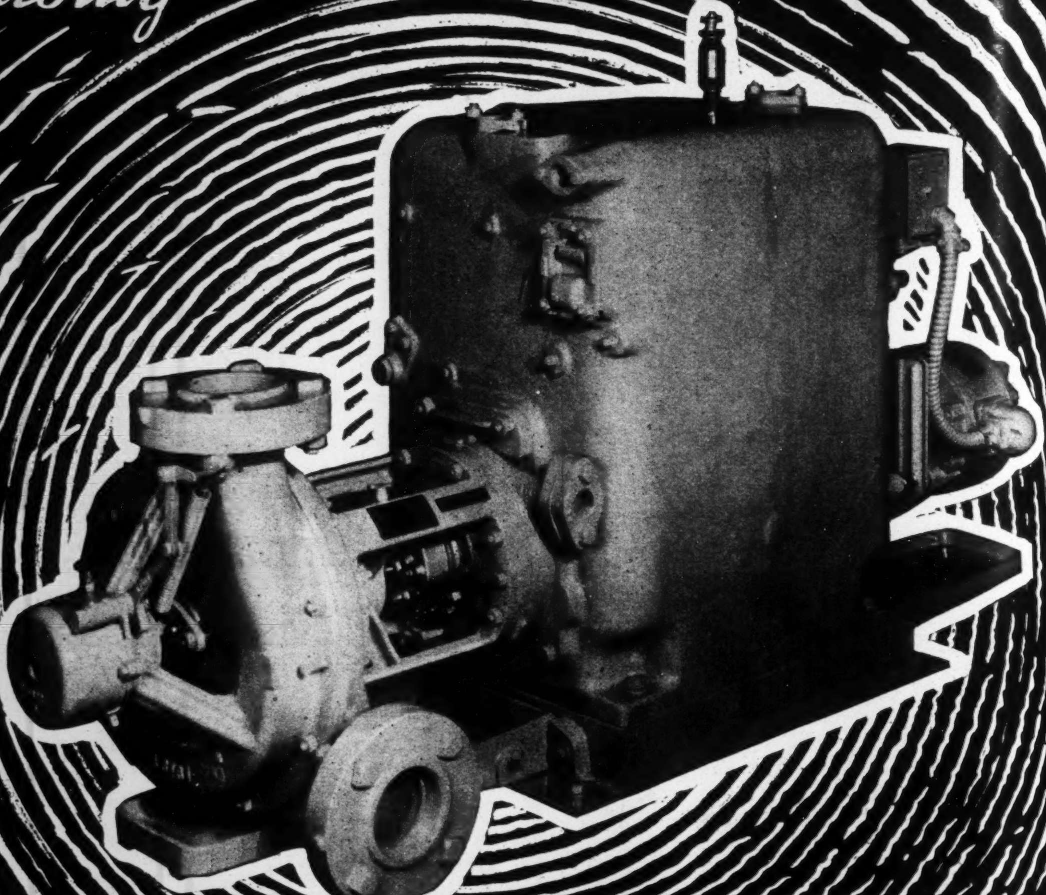

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VARTIME FUEL EFFICIENCY

Fundamentals of Coal Combustion Outlined by Kalman Steiner to Aid Operating Men in Meeting the Growing Need for Fuel Conservation

HE UNITED States Bureau of ines is sponsoring a concerted na- onal fuel efficiency drive to en- urage conservation of coal and her fuels by more efficient utiliza- on. The drive aims at a sufficient duction in the annual coal con- mption to avert the need for ra- oning coal, for it is the belief of al authorities that rationing can avoided if the men principally ncerned—the operating engineers will make a conscientious effort raise their operating standards. n emergency exists. Operating en are called upon to meet that mergency. This brief review of the fundamental technology should assist engineers in analyzing some of the factors in the problem and working out the solution.

A growing sense of the need for fuel conservation during the past decade or two has resulted in more investigation of and publicity about the matter than perhaps in all preceding years of coal consumption. Government agencies, national technical societies, trade associations, college experiment stations, state geologic surveys, and other groups have during the past 15 years issued innumerable papers, bulletins, circulars, reports, investigations, analyses, and other information and data dealing with some aspect of coal utilization. Repeatedly, since about 1930, conferences have been held to discuss the nature, properties, and performance of solid fuels, and the best techniques for securing most effective results from their combustion. In all this vast amount of literature the engineer, had he the time to peruse all of it, would probably find the answer to almost any problem with which he might be confronted, and the procedures for accomplishing adequate and proper burning of his fuel, whatever might be the kind or grade. But it would require many hours of an engineer's time to read all that has been published on any single aspect of coal technology. It is the aim here to present a condensed review of that literature and to state the elementary facts upon which efficient plant operation must be based.

Coal is not a single or simple substance. On the contrary, it is a complex mixture of chemical compounds, few of which have been isolated or identified. There is no universal or single method for burning coal; there is no established procedure for carrying on coal combustion or maintaining clearly understood firebox conditions. There is no one coal that can be burned under all conditions or in all applications. There is no one application that can use all kinds of coal. Most coals by their nature impose close restrictions on the manner in which they can be burned. Most plants by their nature impose close restrictions upon the kind of coal that can be burned in them. Clearly, then, many technical factors are involved in the problem of attaining fuel efficiency.

Innumerable papers, bulletins, circulars, reports, investigations, analyses, and other information and data dealing with some aspects of coal technology or utilization have been issued during the past 15 years and more. Had he time to peruse it all, the engineer could probably find the answer to almost any problem with which he might be confronted. It is the aim here to present a condensed review of the subject, and to state the elementary facts upon which efficient plant operation must be based, in order to assist in the growing need for eliminating fuel waste.

Coal does not occur uniformly throughout our country. There are many economic factors to be considered in its mining and distribution. Transportation is a major item in the final selling price. A coal that might be ideally suited to a certain application at a given place may cost too much at that location. Clearly, then, certain economic aspects must be considered in selecting a coal.

To try to encompass a complete story of coal within a short article is obviously impossible. Yet it is equally true that because of the very complexity of the coal situation the engineer responsible for selecting and burning a coal must have at least a working knowledge of coal science. The best way to begin a consideration of that science is by investigation of the coal itself.

Coal was formed through the geologic eras from vast accumulations of vegetal matter, principally trees and their organs and accessories: trunks, bark, twigs, branches, leaves, spores, roots, and waste products. Two factors chiefly determined the characteristics of the resultant coal. The first was bacterial decay—the kind, and extent or degree of completion. The second was intensity and duration of subsequent pressures and temperatures applied to the decayed vegetal mass in succeeding upheavals and changes in the earth's crust.

Geologists have portrayed a fascinating story of the course of coal formation, but for our purposes we will have to begin a study of coal with its nature and properties as it exists today. Coal deposits occur in layers of varying thickness and at various depths below the surface. Some deposits are so close to the surface the coal is mined by scooping it up after first stripping off the overburden; these are known as strip mines. More generally, coal is reached by sinking shafts and then branching horizontally into tunnels. Regardless of the method of mining, the care expended by the miner in taking the coal without including excessive debris, clay, rock, slate, and other extraneous material, and the diligence of the mine operator in removing from the mined coal as much as possible of the non-coal matter that was brought above ground, will significantly affect the quality of the coal sent to market.

As with all fuels, the combustible portion of coal consists of a mixture of compounds of carbon and hydrogen, and—as with all fuels—there are present certain impurities consisting of compounds of sulfur, nitrogen, phosphorus and metals. A complete identification of all compounds present in coal would be impossible, and in fact would serve little practical purpose. There are two types of laboratory analyses made of coal: the ultimate analysis and the proximate analysis. The ultimate includes moisture, ash, sulfur, carbon, hydrogen, oxygen, and nitrogen. The proximate consists of moisture, ash, sulfur, fixed carbon, and volatile matter. The laboratory generally includes a calorific value. Each is useful in classifying coal according to rank or scientific grouping. The proximate is more useful in indicating the grade or quality of a coal, and is the one generally used by engineers. However, since engineers will find more or less frequent reference to coal rank, a short discussion may be found helpful.

In the discussion of coal rank or classification, it has been found convenient to consider the coal substance alone, as distinct from the coal mass which includes moisture and ash. Hence tabular data will often be designated "moisture and ash free basis." The advantage of this method is obvious. The moisture and ash content are often incidental, and their values can be altered by and in handling of the mined material. But the constitution of the dry and ash free substance is established by the geologic and biologic sequence of the coal's history. The bulk of the original vegetable matter from which the coal formed was composed of carbohydrates, chiefly cellulose and lignin. Carbohydrates are made up of carbon, hydrogen, and oxygen. The successive transformations in coal formation can be briefly summarized by saying that the most important factor was the loss of oxygen. This was accompanied by decrease in the percentage of volatile matter and increase in the content of fixed carbon. Simultaneously, the coal became harder and denser. All these changes are shown graphically in the accompanying figure, ranging through the successive states of transformation from wood to anthracite.

Proximate Analysis—The array of facts which the chemist most frequently prepares for the engineer is known as a proximate analysis. It involves the direct determination of only one chemical constituent, sulfur. The other items are established by loss in weight when certain physical conditions are imposed upon the sample. The proximate analysis is used so frequently by the engineer in evaluating a coal that a proper understanding of it is fundamental to all combustion engineering of solid fuels. It is not necessary to understand in detail the laboratory technique, but an outline of the procedure will show what is accomplished in a proximate analysis.

"Regardless of the amount of primary air supplied to a grate fire, there cannot be complete combustion unless secondary air is supplied above the fuel bed."

The first constituent determined in a proximate analysis is moisture. It happens that this part of the analysis does not have precise significance. In addition to the water inherent in the coal substance as removed from the mine stratum, extraneous water can be picked up: mine water, wash water, rain, and snow. Furthermore, water can be lost by evaporation as the coal proceeds from the mine to its ultimate destination. Hence the water found in the analysis is the net balance of gains and losses. To add to this confusion, some laboratories report moisture on the sample "as received," which is possibly the most logical. Other chemists prefer to air dry the sample to get rid of superficial water and then determine a value for inherent moisture. Finally, as already mentioned, analyses for purposes of classifying a coal by grade and rank are often reduced to the so-called moisture free basis. But the engineer, called upon to evaluate a coal from the proximate analysis, should look only for the moisture on the "as received" basis, which is determined by heating the sample for 1 hr at 221 F.

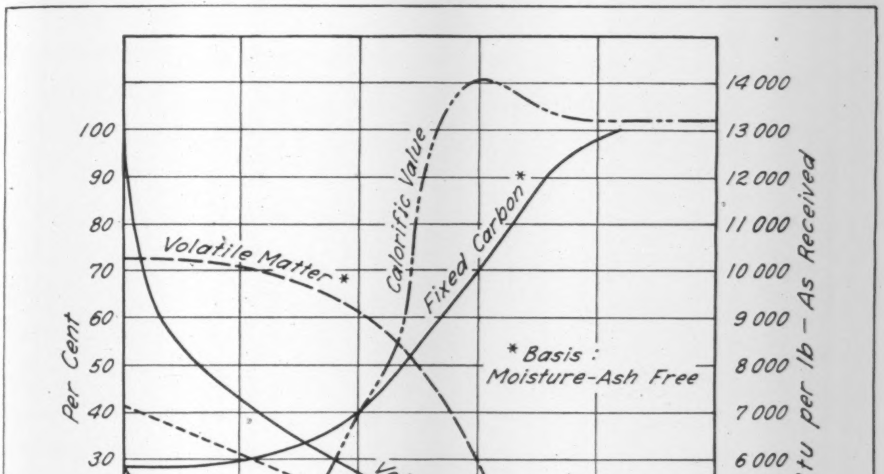
Volatile matter is determined by heating a weighed sample of the "as received" coal at 1740 F for 7 min in a closed, airtight crucible. From the total loss in weight the previously determined moisture is deducted, and the difference called volatile matter. It will be shown below that the volatile combustibles of a coal burn as a gas in the combustion space above the fuel bed. Hence a knowledge of the percentage of volatile is imperative to operating technique.

The percentage of ash is taken as the residue remaining after a sample has been completely burned. Of course, the constituents of the ash, after the coal is burned, are not the same constituents as originally present in the coal, for certain chemical reactions have occurred to alter the mineral matter. But for all practical purposes, the ash determination of the proximate analysis serves as an excellent index of the incombustible residue of the coal.

Fixed carbon is calculated by subtracting from 100 per cent the totals of the moisture, volatile, and ash percentages. This difference is theoretically the portion of the fuel that burns as a solid. It is roughly analogous to the coke formed when the volatile matter is distilled during combustion. In general, fixed carbon burns entirely from primary air supply.

The analysis for sulfur is generally made in a proximate analysis, as well as in an ultimate analysis. The percentage of sulfur does not materially affect the combustion of the fuel, but does introduce other factors, as lowering of ash softening temperature, slagging on furnace walls and tubes, corrosive properties of the flue gases, and chimney and clinker odors. Part of the sulfur is within the coal substance itself, having probably been contained in the plant structure from which the coal was formed. The rest of the sulfur is inorganic, being in the pyrite (iron sulfide) and other minerals gathered up with coal in the mine. The latter can be reduced by cleaning of the coal before shipment. Most sulfur compounds are oxidized during combustion, the sulfur forming SO_2 or SO_3. High sulfur promotes spontaneous combustion of coal in storage.

The calorific value of the fuel is expressed as gross Btu per lb of coal. That is, the bomb calorimeter is contained within a water cooled system and when the coal is burned in the calorimeter the products of combustion are cooled sufficiently to condense the water vapor formed when the hydrogen burns. Hence, the recorded calorific value includes the latent heat of condensation. In ordinary practice, the flue gases are not cooled at any heat absorbing surface where that latent heat can be utilized. Hence, the boiler operating efficiency is promptly charged with the loss of



Adapted from "Fuels and Their Combustion", by Haslam and Russell latent heat—a matter of perhaps 5 per cent of the gross heating value. Also, the gross calorific value does not reflect the heat required to evaporate the moisture contained in the coal as fired.

It is thus seen that actually the proximate analysis, except for sulfur, is a series of physical tests. It can be made rapidly, and no great expense is involved. Engineers have, therefore, adopted the proximate analysis as the guide of coal evaluation. There are, however, other factors sometimes taken into consideration when judging the properties of a coal.

Ash Softening Temperature—In recent years much time and thought has been devoted to study of ash softening temperature. A sample of ash is ground up and a small cone is formed of it and placed in a laboratory furnace. The temperature at which the cone fuses to a spherical lump is called the ash softening temperature. Class 1 ash, considered as refractory or heat resistant, has a softening temperature above 2600 F. Class 2 ash, considered to be of medium fusibility, softens between 2200 and 2600 F. Class 3 or easily fusible ash softens below 2200 F. Although much investigation has been made of this matter of ash fusibility, no one yet has worked out a method for predicting the clinkering properties of a coal from the ash fusibility. In general, of course, the higher the ash softening temperature, the less the likelihood of the ash forming bad clinker. However, repeatedly there have been instances of badly clinkering coals having a higher ash softening point than non-clinkering coals. Furthermore, certain boiler furnaces are operated at temperatures high enough to melt the ash of any coal. It is known that high sulfur coals tend to clinker, but it cannot be said that low sulfur coals will not clinker. Other factors seem to influence clinker formation as strongly as the ash softening temperature: depth of fuel bed, rate of combustion (lb of coal per sq ft of grate per hr), furnace design, and coking property of the coal, among others.

"While regulation of primary air controls the rate of combustion, regulation of secondary air controls the efficiency of combustion."

Other tests and properties of coal of interest to the combustion engineer are plasticity, caking, coking, friability, and grindability. These will be mentioned in relation to their bearing on the performance of coals in the various methods of combustion, discussed below.

How Coal Burns—The first method of burning coal was on grates. Despite the present widespread use of mechanical firing equipment, a great quantity of coal is still burned on grates. Hence, there is much practical significance in the technology of hand firing. In addition, knowledge of the combustion of solid fuels in general is greatly enhanced by study of this fundamental combustion process.

When fresh coal is thrown on a fire, distillation of the volatile matter commences as soon as its temperature has risen to about 650 F. The volatile matter comprises gaseous hydrocarbons (methane, etc.), hydrogen, carbon monoxide, heavier hydrocarbons (tar), and small quantities of carbon dioxide, oxides of sulfur, nitrogen, and nitrogen oxides. The fixed carbon which remains from the distillation constitutes the fuel bed and burns as coke. However, the coke does not burn completely if the bed is more than 4 in. thick, because the product of its combustion in the bed is carbon monoxide, which mingles with the distilled volatiles and with them burns above the fuel bed. It follows that there must be two independent supplies of air for combustion of coal in hand firing, namely, the primary air that enters the fuel bed from below the grate and the secondary air that enters the firebox above the fuel bed.

The Bureau of Mines has conducted extensive investigations of hand firing and has shown that there are four distinct regions in the fuel bed. The lowest is the layer of ash resting on the grate. This is of great importance because it protects the grate from the heat of the fire and also because it preheats the ascending air. Above the ash is the oxidizing zone of incandescent coke, where incoming primary air with a full charge of oxygen burns the coke immediately to carbon dioxide. However, as the gas mixture continues to ris through the fuel bed the oxyge content rapidly falls and is exhausted before reaching the top o the coke layer. As carbon dioxid meets incandescent coke in the absence of oxygen, the dioxide is reduced to the monoxide and the released oxygen combines with mor coke to form more monoxide. At a level about 4 in. above the as layer, the oxygen has completely disappeared. Here begins the third region, known as the reducing zone just described. The fourth region is the distillation zone, where volatiles are formed by destructive distillation of the fresh coal.

Primary Air—The most remarkable fact about combustion of coa on grates is the surprising uniformity in rate of disappearance of oxygen from the primary air at widely varying rates of combustion. The rate of combustion is determined largely by the rate at which primary air is supplied. But even though the rate is varied from as low as 3 lb of coal to as high as 125 lb of coal per sq ft of grate per hr, the oxygen is consumed completely in the relatively narrow oxidation zone, never thicker than 4 or $4\frac{1}{2}$ in. above the ash layer. Hence, we have the significant rule that *regardless of the amount of primary air supplied to a grate fire, there cannot be complete combustion unless secondary air is supplied above the fuel bed.* The corollary to that rule is obvious—regulation of the primary air supply controls the combustion rate.

"Coal is fed in batches; air flow is continuous. The ideal way t fire coal is of course continuously as is attained by mechanica firing."

Secondary Air—We can now turn our attention to what happens in the firebox space above the fuel bed. It should be borne in mind that even though the original coal was low in volatile, as for instance an anthracite with less than 8 per cent volatile matter, the formation of carbon monoxide in the reducing layer of the fuel bed produces a gaseous fuel that must be burned by introducing secondary air above the fuel bed. It has been established that from 40 to 60 per cent of the total calorific value of the fuel is developed in the combustion space above the fuel bed. It is, therefore, of the utmost importance that the secondary air be admitted in correct amount, that it be brought into direct contact with the unburned volatiles, that the mixture be maintained at an elevated temperature to promote complete combustion, and that sufficient time be allowed for completion of combustion before the gases are withdrawn from the firebox or brought into contact with a cool surface. It is customary to refer to these requirements as the three *T's*: time, temperature, and turbulence. However, the *amount* of secondary air is of coordinate importance. It is now possible to draw the second rule for hand firing. While regulation of primary air controls the *rate of combustion, regulation of secondary air controls the efficiency of combustion.*

It should immediately be apparent that a glaring disparity exists in the manner of furnishing coal and air, the raw materials of a grate fire. Coal is fed in batches; air flow is continuous. The ideal way to fire coal is, of course, continuously, as is attained by mechanical firing. A succeeding article will discuss the most efficient methods of hand firing and the latest technological developments in that art. A concluding article will cover the general theory of combustion of coal with stoker firing, and means of attaining high efficiencies with the several types of stokers encountered in commercial practice.

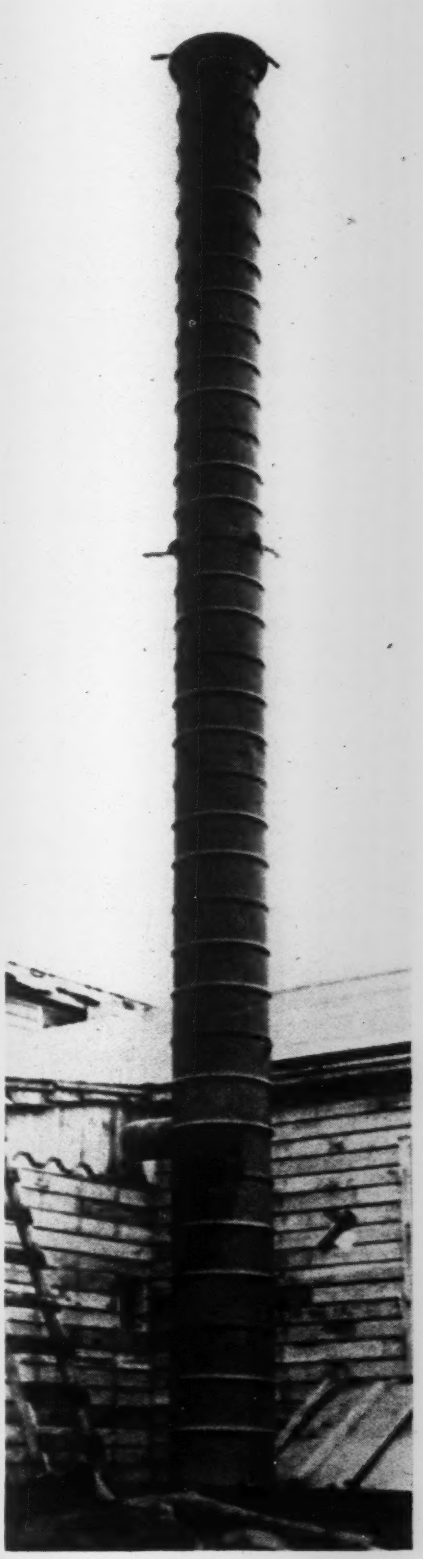
Confer on Possible Changes in Fuel Oils After the War

OVER A hundred refiners and oil burner men met at the Palmer House, Chicago, May 18, to consider a draft of assumptions and basic facts concerning production and use of fuel oils during the first five years after the war. Purpose of the one day conference, held under the chairmanship of I. J. Fairchild, chief of the division of trade standards of the National Bureau of Standards, was to exchange ideas and plans of refining and burner manufacturing interests so that both groups may collectively plan "for changes in oils and in burners which will be necessitated by current and projected changes in refinery practices." The eventual objective is to revise the fuel oils commercial standard, CS12-40, as may be required.

It is assumed that an ample supply of crudes will be available, even though the exact sources and types are not predictable; it is expected that fuel oils may have a higher sulfur content, in view of the decreasing availability of low sulfur crudes. This assumption does not, however, take into account future exploitation, according to some of the conferees. Higher sulfur content fuel oils will present an odor problem to burner manufacturers and users, it was pointed out, as combustion is never 100 per cent perfect.

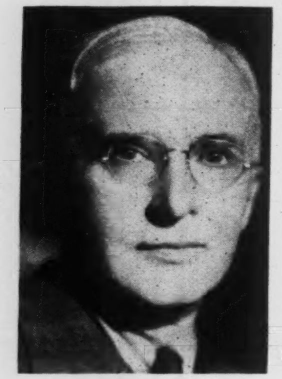
A large part of the discussion revolved about the possible wider use of the catalytic cracking process and the effect of the wider use of this process on the characteristics of available fuel oils after the war. This process tends to produce lower API gravity distillate fuels for the same distillation range and residual fuel oils of different gravity-viscosity relationships than have previously been available, it was stated.

In general, the refinery men at the conference seemed to favor rather broad standards for the various fuel oils, with burners to be designed to handle efficiently the lowest quality of oil that might be encountered in any part of the country. The burner men seemed to lean toward fairly close or definite standards for each oil, which they felt would simplify the design of burners. Heating oils of higher Btu content per gallon were predicted by some of the refinery people.



THIRTY-SIX EQUALS ONE

Thirty-six oil drums add up to one smokestack in the book of Uncle Sam's ingenious Seabees, somewhere in the Aleutians. The thrifty construction-destruction Navy men welded the empty drums together to make this stack, which is more than 160 ft high, for a boiler heating the dispensary at an Aleutian base. (Acme)



Sam Lewis' Page

In this regular feature, informal comment on heating, piping, and air conditioning problems and their solutions is given — at the request of the editors — by Samuel R. Lewis, consulting engineer, and a member of HPAC's board of consulting and contributing editors

A CONTEMPORARY architectural magazine shows interior views of many interesting offices, presumably to be occupied by artists, decorators, advertising executives, and the like. The outstanding characteristic of each picture and the descriptive matter accompanying it is that something must be done to conceal the radiator. In many cases beautiful curtains running from floor to ceiling are provided. The curtains, of course, generally conceal the window as well as the radiator, and thereby incidentally will reduce the heat loss to the window from the room by providing an additional barrier. They also reduce the influence of the radiator on the room and may increase the heat loss to the outside from the radiator, since the air chamber between the curtain and the window will become very warm.

One who opens his office window frequently for some air supply realizes the impracticability of beautiful fabric curtains when considered in the light of dust.

I know one New York office where the windows open on an ugly court and have conventional radiators below them. There was installed a second barrier between the window-wall and the room, made of translucent glass. This barrier has easily opened casements so that they can be closed or left ajar for air and heat as may be convenient. These casements, essentially double windows, seem to me to be far more acceptable than curtains. A similar arrangement may be seen in the east windows on the fifth story in a prominent Chicago department store.

There are more favorable locations in rooms for air delivery than through windows. Ventilation provided by mechanical means works well from ceiling inlets and outlets or from inlets high in side walls. Granted adequate dust filtration of the entering air, our friends, the interior decorators, may receive a benediction on the beautiful curtains and expense for redecorating walls and ceilings will be very materially reduced.

* * *

MECHANICALLY OPERATED valves which control the rate of flow in steam heating systems, especially in heavy duty service, require much maintenance attention. The volume of steam, for example, passing from a high pressure condition in the boilers through a reducing valve to a low pressure heating system varies through an extremely wide range. If the orifice in the reducing valve is based on the maximum load, the much smaller steam volume required during most of the heating season will keep the orifice so nearly closed as to wear grooves in the disc and seat of the valve. It follows that eventually the valve will leak so badly as to be useless. The same results appear where valves are installed to modulate the temperature in large zones of heating systems.

Manufacturers of reducing valves and control valves generally recommend selection of exceedingly small valves, hoping that the higher lift between disc and seat thus attained will reduce the erosion—called wire drawing—to a minimum. The trouble with this remedy is that on cold days the too-small valves refuse to pass sufficient steam. This refusal has made it necessary in some instances to replace the valves with larger ones.

I suggest that the wise designer should install two such valves in parallel. One, possibly the smaller of the two, should open first, and do the entire job in mild weather and light loading, with the second valve never opening except after the first one has proved unable to pass enough steam. This relaying action easily is attainable by adjustment of the springs or weights or other variable mechanisms in the valves.

* * *

ONE MEETS the problem of oil mist in heavy duty machine shops. Sometimes this spray thrown into the air by high speed grinding becomes a serious menace, dripping from lights and beams, polluting the air, making the floor slippery.

It is possible to remove and to reclaim much of this oil by electrostatic precipitation. It is also possible to remove the surplus oil along with vast quantities of air by mechanical exhaust ventilation. The weakness of this latter scheme is that the ducts, fan, etc., soon are loaded with oil, and the ducts become a fire hazard and the fan blades become so coated as to lose much of their efficiency.

In one blackout machine shop, it appears from my recent observations that the introduction and distribution of approximately 4 cfm of clean, outside air per square foot of floor area, with corresponding relief outlets through the roof, operating due to the pressure from the room, has alleviated the oil mist—apparently by dilution. The incoming air is diffused in such manner as to bring about a very noticeable but also locally adjustable air movement around the body of each workman.

COMPARATIVE ENGINEERING DATA ON REFRIGERANTS GIVEN IN NEW TABLES

NEW REFRIGERANTS whose field of use is not well defined are appearing today, and others may be expected in the future. Of the several available refrigerants, "Freon-12" and ammonia are the most widely used. "Freon-12" is employed in air conditioning work and is finding many uses in industrial refrigeration also. Ammonia is widely used in ice making plants and in industrial applications. For centrifugal machines, refrigerants like "F-11" and "F-113" are used because of their desirable properties for this type of compressor. Other new refrigerants will probably find their places in definite types of applications in the expected postwar expansion of refrigeration and air conditioning.

In deciding which refrigerant to use under a specific set of conditions, tables are needed which give engineering data such as weight and volume of refrigerant to be circulated per ton, and horsepower and capacity. Such tables, in addition to the basic tables of thermodynamic properties, are of value in showing at a glance just which refrigerant would be desirable under a given set of circumstances. For this reason various sets of tables have been prepared for "Freon-11," -12, -21, -22, and -113, ammonia, methyl chloride, and water vapor. These tables, which will appear in this and subsequent issues, enable the user to make rapid comparisons of the important basic data needed in deciding whether a refrigerant is suitable for a given set of circumstances. Temperatures are shown in degrees Fahrenheit.

"Freon-22"—Weight of refrigerant to be circulated

(*Saturated vapor leaving evaporator*)

Lb per min per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve												
	60	65	70	75	80	85	90	95	100	105	110	115	120
-20	2.66	2.72	2.78	2.84	2.91	2.98	3.06	3.14	3.22	3.32	3.41	3.52	3.63
-15	2.64	2.70	2.76	2.82	2.89	2.96	3.03	3.11	3.20	3.28	3.38	3.48	3.59
-10	2.62	2.68	2.74	2.80	2.86	2.93	3.01	3.08	3.17	3.25	3.35	3.45	3.55
- 5	2.60	2.66	2.71	2.78	2.84	2.91	2.98	3.06	3.14	3.22	3.32	3.41	3.52
0	2.58	2.64	2.69	2.76	2.82	2.89	2.96	3.03	3.11	3.20	3.29	3.38	3.49
5	2.57	2.62	2.68	2.74	2.80	2.86	2.94	3.01	3.09	3.17	3.26	3.35	3.45
10	2.56	2.61	2.66	2.72	2.78	2.85	2.92	2.99	3.07	3.15	3.24	3.33	3.43
20	2.52	2.57	2.63	2.68	2.74	2.81	2.88	2.95	3.02	3.10	3.19	3.28	3.37
30	2.49	2.54	2.59	2.65	2.71	2.77	2.84	2.91	2.98	3.06	3.14	3.22	3.32
40	2.46	2.51	2.56	2.62	2.67	2.73	2.80	2.87	2.94	3.01	3.09	3.18	3.27
50	2.44	2.48	2.53	2.59	2.64	2.70	2.76	2.83	2.90	2.97	3.05	3.13	3.22
60	2.41	2.46	2.51	2.56	2.61	2.67	2.73	2.80	2.86	2.94	3.01	3.09	3.18

"Freon-22"—Volume of refrigerant to be compressed

(*Saturated vapor leaving evaporator*)

Cfm per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve												
	60	65	70	75	80	85	90	95	100	105	110	115	120
-20	5.52	5.64	5.77	5.90	6.04	6.19	6.35	6.52	6.69	6.88	7.08	7.30	7.53
-15	4.92	5.03	5.14	5.26	5.38	5.51	5.65	5.80	5.96	6.12	6.30	6.49	6.69
-10	4.40	4.49	4.59	4.70	4.80	4.92	5.05	5.18	5.32	5.46	5.62	5.78	5.96
- 5	3.94	4.02	4.11	4.20	4.30	4.41	4.52	4.63	4.76	4.88	5.02	5.17	5.33
0	3.54	3.62	3.69	3.78	3.86	3.96	4.05	4.16	4.26	4.38	4.50	4.64	4.78
5	3.19	3.25	3.32	3.40	3.48	3.56	3.65	3.74	3.83	3.94	4.05	4.16	4.29
10	2.89	2.95	3.01	3.08	3.15	3.22	3.30	3.38	3.47	3.56	3.66	3.77	3.88
20	2.36	2.41	2.46	2.51	2.57	2.63	2.69	2.76	2.83	2.90	2.98	3.07	3.16
30	1.95	1.98	2.03	2.07	2.12	2.16	2.22	2.27	2.33	2.39	2.45	2.52	2.59
40	1.61	1.65	1.68	1.72	1.75	1.79	1.84	1.88	1.93	1.98	2.03	2.08	2.14
50	1.35	1.37	1.40	1.43	1.46	1.50	1.53	1.57	1.60	1.64	1.69	1.73	1.78
60	1.13	1.15	1.18	1.20	1.23	1.26	1.28	1.31	1.34	1.38	1.41	1.45	1.49

Engineers need information on weight and volume of a refrigerant to be circulated, and horsepower and capacity, in order to decide whether a refrigerant is suitable for a given set of circumstances. Tables of such data for a number of refrigerants have been prepared. Those for "Freon-22" are presented here, others will appear later.

The tables are easy to use. The temperature of the liquid ahead of the expansion valve is equal to the condensing temperature if no subcooling takes place. However, a small amount of subcooling usually takes place in most condensers. It is reasonably safe to figure that the temperature of the liquid ahead of the expansion valve will be about 5 F lower than the actual condensing temperature. The actual condensing temperature corresponding to any given head pressure can, of course, be found in the tables for saturated liquid.

The values for "Freon-22" are preliminary and subject to later revision, as they were prepared from preliminary tables of the thermodynamic properties of this refrigerant. Hence, inaccuracies and discrepancies may exist. However, the values are sufficiently accurate to give a general idea of its use.

"Freon-22" was developed specifically for use in the range of evaporator temperatures from 0 down to —150 F and is not recommended by the manufacturer for use at temperatures as high as 60 F, due to high head temperatures and temperatures of compression. Other "Freon" refrigerants are available for the higher temperatures. Values for evaporator temperatures above 0 F are shown in the accompanying tables, however, for the sake of consistency of the entire set of tables and for theoretical comparisons. A later set of tables is planned to cover the extreme low temperature range.

"Freon-22"—Theoretical horsepower of refrigerating compressors

(Saturated vapor entering compressor)

Horsepower per ton

Evap Temp	Condensing temperature 60	65	70	75	80	85	90	95	100	105	110	115
-20	1.04	1.12	1.21	1.30	1.39	1.49	1.59	1.70	1.81	1.92	2.04	2.18
-15	0.954	1.03	1.12	1.20	1.29	1.38	1.48	1.58	1.69	1.80	1.92	2.04
-10	0.873	0.949	1.03	1.11	1.20	1.29	1.38	1.48	1.58	1.69	1.80	1.92
- 5	0.794	0.868	0.944	1.02	1.11	1.19	1.28	1.38	1.47	1.58	1.68	1.80
0	0.719	0.790	0.863	0.941	1.02	1.10	1.19	1.28	1.37	1.47	1.57	1.68
5	0.646	0.715	0.785	0.860	0.936	1.02	1.10	1.18	1.27	1.37	1.47	1.57
10	.571	.637	.706	.777	.850	0.927	1.01	1.09	1.17	1.26	1.36	1.46
20	.438	.500	.564	.630	.698	0.768	0.842	0.918	0.997	1.08	1.17	1.26
30	.315	.373	.433	.495	.558	0.623	0.690	0.762	0.834	0.911	0.992	1.08
40	.199	.254	.309	.368	.426	0.486	0.549	0.616	0.681	0.752	0.827	0.906
50	0.0942	0.144	0.196	0.251	0.307	0.362	0.421	0.483	0.544	0.609	0.678	0.752
60		.0446	.0934	.145	.197	.250	.304	.362	.418	.479	.543	.610

"Freon-22"—Theoretical capacity of refrigerating compressors

(Saturated vapor leaving evaporator)

Tons per cfm of vapor compressed

Evap Temp	Temperature of liquid ahead of expansion valve 60	65	70	75	80	85	90	95	100	105	110	115	120
-20	0.181	0.177	0.173	0.169	0.166	0.162	0.158	0.153	0.149	0.145	0.141	0.137	0.133
-15	.203	.199	.195	.190	.186	.181	.177	.172	.168	.163	.159	.154	.149
-10	.227	.223	.218	.213	.208	.203	.198	.193	.188	.183	.178	.173	.168
- 5	.254	.248	.243	.238	.232	.227	.221	.216	.210	.205	.199	.193	.188
0	0.282	0.277	0.271	0.265	0.259	0.253	0.247	0.241	0.234	0.228	0.222	0.216	0.209
5	.314	.307	.301	.294	.288	.281	.274	.268	.261	.254	.247	.240	.233
10	.346	.339	.332	.325	.318	.311	,303	.296	.288	.281	.273	.266	.258
20	.424	.415	.406	.398	.389	.380	.371	.362	.353	.344	.335	.326	.317
30	.514	.504	.494	.483	.473	.462	.451	.441	.430	.419	.408	.397	.386
40	0.620	0.608	0.595	0.583	0.570	0.558	0.545	0.532	0.519	0.506	0.494	0.480	0.467
50	.742	.728	.713	.698	.684	.668	.654	.638	.623	.608	.593	.577	.561
60	.863	.867	.850	.833	.815	.797	.779	.761	.743	.726	.707	.689	.670

Design and Control of
year 'round comfort
Air Conditioning Systems

Air, after being cooled and dehumidified, can be reheated in a number of ways, the most obvious of which is either by steam or hot water. In central air conditioning systems where the reheating coil is placed immediately after the cooling coil or air washer, reheating can be accomplished more cheaply and equally satisfactorily by using the hot refrigerant gas discharged from the compressor. In this case, the reheating coil is supplied with hot gas directly from the compressor. Part of the condensation of the refrigerant is accomplished in the air reheating coil, the balance taking place in the conventional water cooled condenser, as will be illustrated later.

Regardless of whether reheating is accomplished by means of steam, hot water, or condenser gas, either one of two arrangements can be used. In the arrangement shown in Fig. 6, the reheating coil is placed immediately after the cooling coil. All of the air, after having first been chilled and dehumidified, is then reheated by being passed through the reheating coil. The supply of steam or hot water

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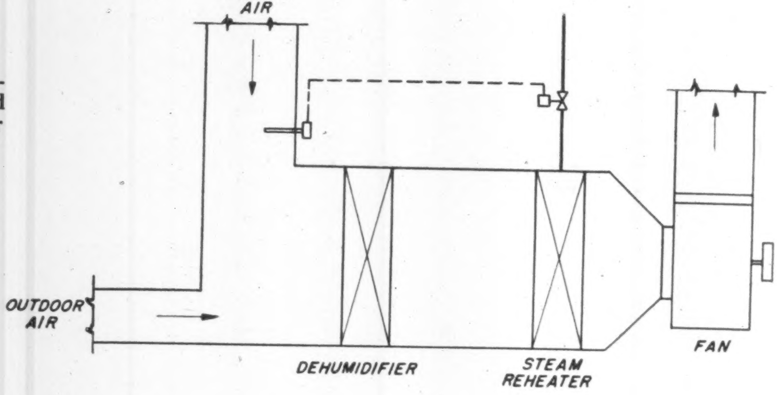

RETURN AIR
OUTDOOR AIR
DEHUMIDIFIER
STEAM REHEATER
FAN

Fig. 6—Method of reheating dehumidified air with steam reheater

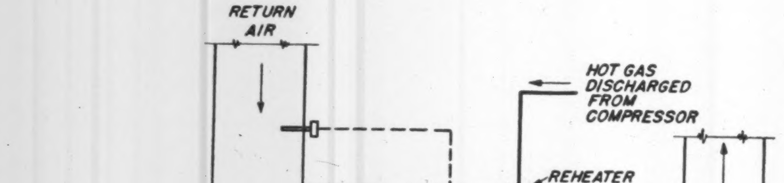

RETURN AIR
HOT GAS DISCHARGED FROM COMPRESSOR
REHEATER
DAMPER
OUTDOOR AIR
DEHUMIDIFIER
FAN
WATER
CONDENSER

Fig. 7—Scheme for reheating dehumidified air with refrigerant gas from compressor

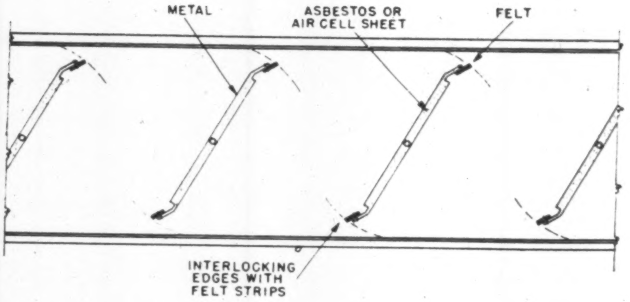
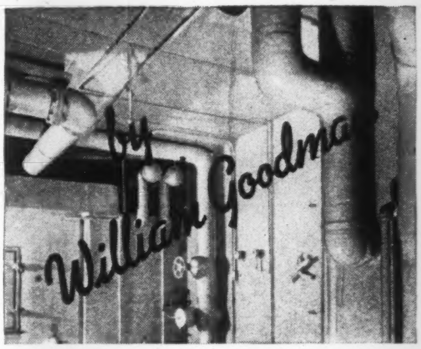

METAL
ASBESTOS OR AIR CELL SHEET
FELT
INTERLOCKING EDGES WITH FELT STRIPS

Fig. 8 — Suggested construction for face dampers shown above



REHEATING

The basic principles that govern the design and control of year 'round conditioning systems are organized and discussed in a systematic manner in the series of articles of which this is the fourth, and which is devoted to methods of reheating air, the advantages and disadvantages of reheating, and the cost of reheating in order to control relative humidity as well as dry bulb temperature in air conditioned spaces. No attempt is made to show a collection of control and equipment arrangements except insofar as they are needed to illustrate the various points discussed. Instead, the methods of accomplishing certain desired results in air conditioning systems and the broad basic principles that govern the applicability of different types of conditioning systems and controls are presented from a refreshingly new viewpoint. Those who are now designing and will be designing comfort air conditioning systems for postwar installation will find this discussion timely and practical, for no matter what the developments of the future, basic principles will always govern. Mr. Goodman is consulting engineer for the Trane Co., and member of HPAC's board of consulting and contributing editors.

is controlled by means of a valve which, in turn, is controlled from a dry bulb thermostat situated either in the room or preferably in the return air duct. The relative humidity can be controlled in a number of ways, which will be discussed later; for the moment, we are concerned only with reheating.

Another method illustrated in Fig. 7 uses a reheating coil and bypass. Here also the reheating medium can be steam, hot water, or hot gas discharged from the compressor. All of the air is cooled and dehumidified. However, part of the air flows through the reheating coil and part through the bypass. The amount of air flowing through the reheat coil is controlled by face and bypass dampers which, in turn, are controlled by a dry bulb thermostat situated in the return air. Insofar as the temperature of the air supply and the conditions in the conditioned space are concerned, this method is exactly equivalent to the one in which all of the air is reheated. The temperature of the mixture of bypassed and reheated air leaving the fan will be exactly the same under a given set of conditions as the temperature of the air in a system in which all of the air is reheated.

The method of control by face and bypass dampers is just as satisfactory for steam and hot water coils as the one shown in Fig. 6. However, its chief merit lies in the fact that when reheating is accomplished by means of hot refrigerant gas, no valves are needed to control the hot gas and no special devices are needed for returning the condensed refrigerant to the receiver such as are required when the flow of hot gas into the reheating coil is controlled by means of a modulating valve. As shown in Fig. 7, all of the hot gas is discharged through the reheating coil.

The face and bypass dampers operated by the dry bulb thermostat control the amount of reheat. When only a small amount of reheating is required, most of the gas plus the condensate flows through the outlet connection at the bottom into the top of the condenser. The balance of the condensation is accomplished in the conventional water cooled condenser. The head pressure in the two condensers can be maintained by means of an automatic water valve. When a large percentage of the condensation of the refrigerant takes place in the reheating coil, the pressure actuated water valve throttles the supply of water to the water condenser. As a result, the head pressure can be maintained constant regardless of the amount of condensation that takes place in the reheating coil. Furthermore, there is, of course, a saving of water whenever the air is reheated. This method of controlling the reheating by face and bypass dampers is especially desirable when hot gas is used because it is simple in application and effective in operation. Other methods of controlling reheating with hot gas refrigerant have been described by S. F. Nicoll in his paper, Reheating by Means of Refrigerant Compressor Discharge Gas, which appeared in the ASHVE Journal Section of the December 1940 issue of HPAC, pp. 736-741.

A set of face dampers is shown on each side of the reheating coil of Fig. 7. A double set of face dampers is necessary because with only one set of face dampers there is likely to be considerable heating of the air due to impingement, eddy currents, and leakage. A desirable construction for the dampers is illustrated in Fig. 8. Each plate of the damper should be constructed of a double strip of sheet metal with a sheet of asbestos or air cell insulation sandwiched between the two sheets of metal. In addition, the interlocking edges of the damper should be lined with felt in order to minimize leakage. With dampers constructed as shown in Fig. 8, unwanted reheating can be kept to a minimum.

A zone of an air conditioning system can be either a large number of spaces which have common heat and moisture load characteristics, or it can mean an individual space occupied by only one person. A zone is any space controlled by a single thermostat whether it be large or small. Because of varying exposures, it is quite common today to divide large air conditioned spaces into different zones, each with its own control.

When reheating is needed in zoned systems supplied with chilled and dehumidified air from a central plant, the reheating coils can be situated at the dehumidifying coil and individual ducts run to each zone. Under these conditions, reheating can, of course, be accomplished by using the hot refrigerant gas, or by steam or hot water. However, individual ducts running to widely scattered zones may be ex-

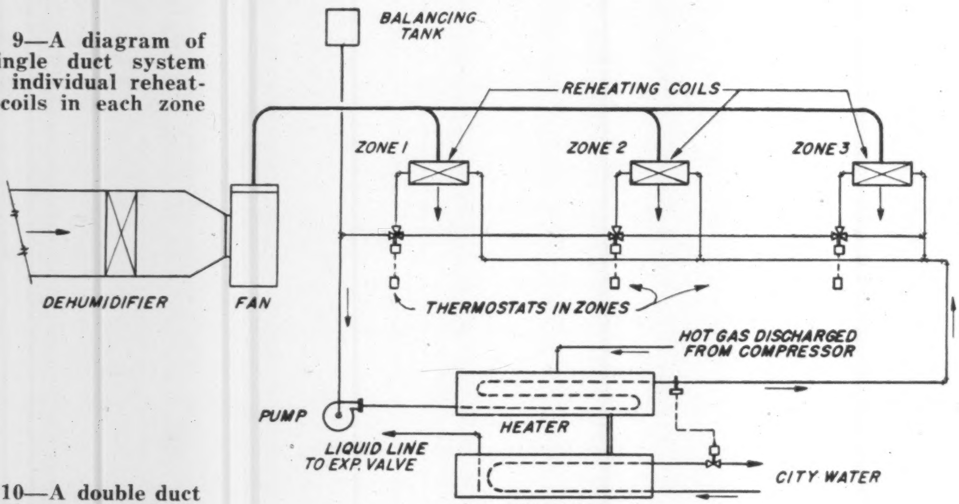

BALANCING TANK
REHEATING COILS
ZONE 1
ZONE 2
ZONE 3
DEHUMIDIFIER
FAN
THERMOSTATS IN ZONES
HOT GAS DISCHARGED FROM COMPRESSOR
PUMP
HEATER
LIQUID LINE TO EXP. VALVE
CITY WATER
CONDENSER

Fig. 9—A diagram of a single duct system with individual reheating coils in each zone

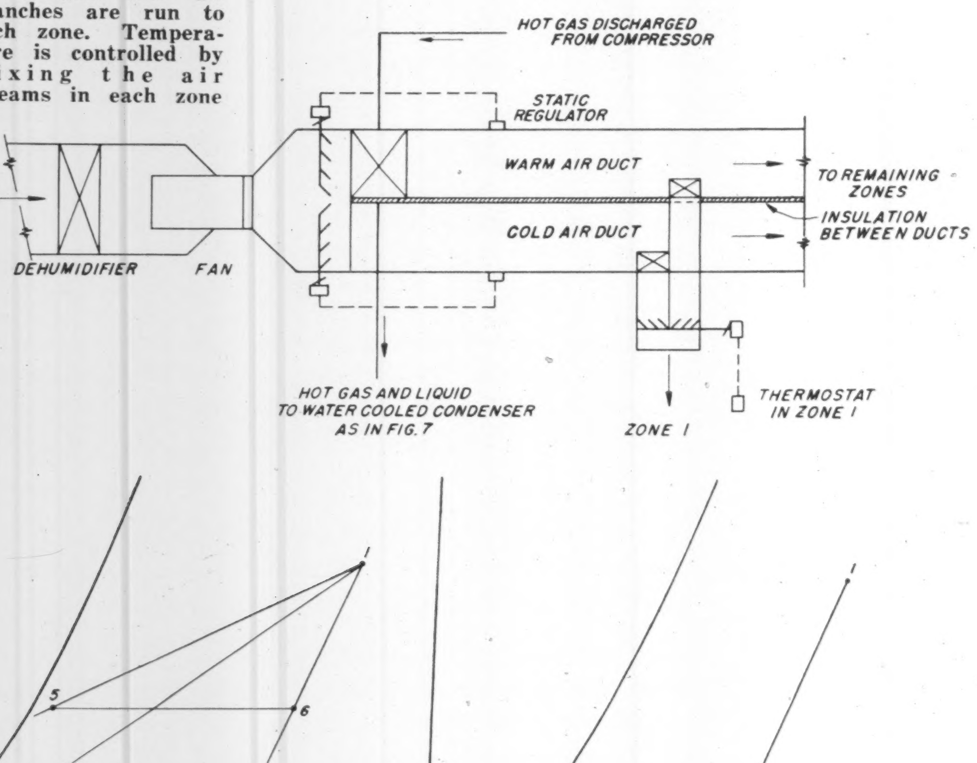

HOT GAS DISCHARGED FROM COMPRESSOR
STATIC REGULATOR
WARM AIR DUCT
TO REMAINING ZONES
INSULATION BETWEEN DUCTS
COLD AIR DUCT
DEHUMIDIFIER
FAN
HOT GAS AND LIQUID TO WATER COOLED CONDENSER AS IN FIG. 7
THERMOSTAT IN ZONE 1
ZONE 1

Fig. 10—A double duct reheating system. Both warm and cold air branches are run to each zone. Temperature is controlled by mixing the air streams in each zone

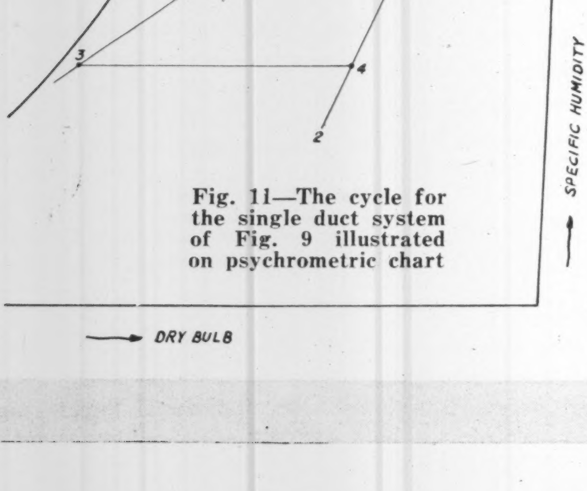


Fig. 11—The cycle for the single duct system of Fig. 9 illustrated on psychrometric chart

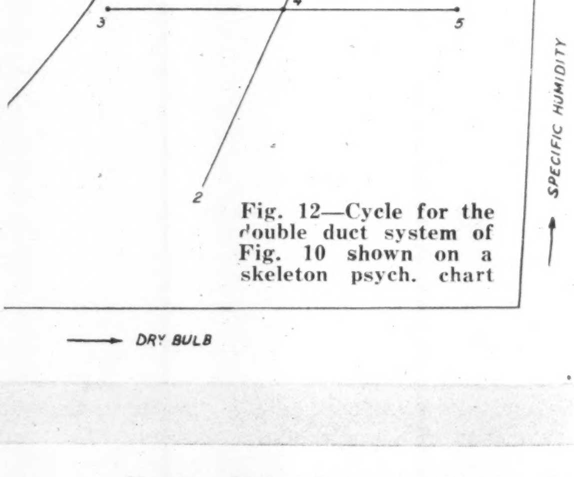


Fig. 12—Cycle for the double duct system of Fig. 10 shown on a skeleton psych. chart

pensive to install. To avoid the use f individual ducts to scattered ones, one of two methods is commonly used in zoned systems. In he first system, illustrated in Fig. 9, a single duct system is used to istribute the chilled and dehumidified air to all of the various zones. Reheating coils are installed in the branch ducts to each zone, as hown. The amount of reheat added is, of course, controlled by a dry bulb thermostat in each zone. Because it is undesirable to pipe refrigerant around a building, steam or hot water is employed as the reheating medium when individual reheating coils are used in each zone.

Water from Condenser

For reheating purposes, warm water can be obtained by means of an auxiliary condenser, as illustrated in Fig. 9. Two condensers are provided, one for the reheating water and one for city water. The hot gas is discharged directly from the compressor into the auxiliary condenser, which is placed above the city water condenser. The warm water is maintained at a given temperature of, say, about 100 F by means of a thermostat inserted in the water line leaving the auxiliary condenser; this thermostat controls the valve in the city water line. As the temperature of the reheating water falls, the thermostat tends to close the valve in the city water line, thus throttling the city water supplied to the main condenser. In this manner the condensing temperature is raised, which results in a rise in the temperature of the reheating water. Although this method of reheating is economical insofar as the use of city water for condensing purposes is concerned, it is uneconomical in that a fixed high head pressure is always maintained on the system even when colder condensing water is available. However, it does completely eliminate the need for providing steam for reheating purposes.

Reheating coils utilizing low temperature water at, say, about 100 F must of course be considerably larger than reheating coils utilizing relatively high temperature steam at about 215 F. For this reason, and because of the extra condenser, the cost of a zoned system utilizing warm water heated by condenser gas is likely to be relatively high.

Another method that can be used and which has the very desirable advantage of permitting hot gas to be readily used for reheating is the double duct system illustrated in Fig. 10. Two ducts are used to carry conditioned air around the entire building; a stream of chilled air is carried by one duct and a stream of reheated air by the second duct. Mixing dampers under control of a thermostat are placed in the various zones to control the air delivered to the zone. In this way a mixture of heated and cooled air is supplied to each zone in accordance with the demands of the thermostat in the zone. However, the total volume of air delivered to each zone never varies; it is always constant. Dampers under control of static pressure regulators are situated at the entrance to each duct; these dampers automatically shift the air between the two ducts. Note particularly that even though the dry bulb temperature of the warm stream of air is higher than that of the cold stream of air, the dew point temperatures of both streams of air are exactly the same.

Note also that the double duct system is essentially exactly the same as the reheat coil with a bypass illustrated for the central system of Fig. 7. The only difference is that instead of mixing the streams of warm and chilled air immediately after the reheat coil, the streams of air are mixed at various locations under control of their own dampers.

The two main dampers at the entrance of each duct in Fig. 10 should be independently controlled by separate static pressure regulators, one regulator in each duct. In this manner, the air delivered by the fan will always be shifted between the two ducts in accordance with the opening and closing of the dampers on the branch duct. For example, if the room temperatures should be rising and the branch dampers on the warm air ducts closing while the cold air dampers are opening in the various zones, the static pressure regulators would close the damper ahead of the reheat coil and open up the main damper at the entrance to the cold air duct.

The double duct system is very flexible in use as it permits branch ducts to be cut into the main ducts at any time and at any place. This is particularly desirable in office buildings where office spaces are frequently changed. All that it is necessary to do is to extend branches to the new spaces and install mixing dampers and a thermostat. Electrical or pneumatic connections to the thermostat are small and easily handled. There are no problems involved in piping reheating coils. Condensate returns from steam reheating coils can sometimes be somewhat of a problem.

The double duct system has the disadvantage that each of the double ducts must be large enough to carry the entire air supply. In extreme summer weather, practically all of the air will be delivered through the cold air duct, whereas in winter practically all of it must be delivered through the warm air duct. Higher velocities are coming into general use in air conditioning work, and with some sound deadening material added to sections of the duct, it may be possible to use small enough ducts so that in many places there may be sufficient space available for installation of a double duct system. However, the double duct system always does require more room for its installation than a single duct system. Each job must be studied on its own merits both as to space available and as to operating costs in order to determine whether to install a double duct system or a single duct system with reheating coils.

Advantages of Reheating

Aside from the very important and primary requirement of being able to maintain the humidity in a space regardless of the sensible heat load, there are two other very important advantages in controlling zones by reheating. The first advantage is the fact that it is possible simultaneously to cool one zone while another zone is being heated. This ability to simultaneously heat and cool is very important during the in-between seasons. Thus the shady side of a building on a 60 F day may require some heat while zones on the sunny side may require cooling.

Another important advantage of control by reheating is the fact that no reversal of the control system is required for winter and summer operation. For example, in systems in which the temperature is controlled either by throttling the air supply or by bypassing the air, the action of the thermostat must be reversed for winter and summer. Thus in summer, when the temperature rises, it is necessary for the branch damper at the zone to *open* to admit more cold air. On the other hand, in winter when the temperature rises, it is necessary for the branch damper to *close* in order to cut down the supply of warm air to the zone. The point at which the action of the thermostat should be reversed from winter to summer operation is always a troublesome one. Usually this reversal is accomplished by means of a thermostat in the outdoor air intake. This thermostat may be set to reverse the action when the outdoor temperature falls to, say, 60 F. But there may be clear, bright days of 55 F when a zone will still require cooling, and there may be other windy, gray days of 60 F when a building may require heating. Reversing the action of a control system in a building at some arbitrarily fixed outdoor temperature is unsatisfactory and productive of operating difficulties during the in-between seasons unless means are provided for simultaneous cooling and heating. The use of reheating control entirely avoids the necessity of reversing the action of the thermostat. The thermostat always acts in the same direction and will provide any necessary cooling or heating of a zone or of a single large space without the necessity of an arbitrary reversal point from winter to summer control.

Reheating Design

Straight reheating systems are either of the single duct type illustrated in Figs. 7 and 9, or of the double duct type illustrated in Fig. 10. The cycle for a single duct system is illustrated on the skeleton psychrometric chart of Fig. 11.

For a room ratio line like *1-2*, it is, of course, necessary that the air be supplied in a condition that can be represented by a point along ratio line *1-2*. For example, the air could be supplied in the condition represented by either point *4* or *6*. Insofar as maintaining condition *1* in the room is concerned, point *4* can be anywhere along line *1-2*. However, the location of point *4* along line *1-2* determines the amount of heat required for reheating. The greater the distance between points *1* and *4*, the smaller the quantity of air that need be supplied to the room. Consequently, the greater the distance between points *1* and *4*, the smaller will be the quantity of heat needed for reheating the air.

As long as heat can be obtained from the condensing refrigerant gas, the quantity of reheat required is in itself not important. However, the quantity of heat required for reheating does have an effect upon the refrigerating capacity if the room ratio line under maximum load conditions is steep like *1-2*. On the other hand, if under maximum load conditions the ratio line is like *1-5* or *1-3* and no reheating is required under maximum load conditions, then the quantity of heat required for reheating has no effect on the maximum refrigerating capacity. Consequently, in systems where reheating is required even under maximum load conditions, the quantity of heat required for reheating must be kept to a minimum. On the other hand, if no reheat is required under maximum load conditions, it is immaterial insofar as the maximum refrigerating capacity is concerned whether the air is supplied in the condition represented by point *4* or point *6* of Fig. 11.

For those systems where reheating is required under maximum load conditions, point *4* should in general be kept as low as possible. The smaller the quantity of air to be supplied to the room, the smaller will be the quantity of reheat required and the lower will be the additional refrigerating capacity required to offset the heat added during reheating. Of course, there are limits to the distance between points *1* and *4*. As points *1* and *4* are first separated, the quantity of heat required for reheating continually decreases to some minimum point, after which further separation of points *1* and *4* results in an increase in the quantity of heat required. (For a discussion of the method of locating point *4* for the minimum quantity of reheat, refer to p. 194 of the author's book, Air Conditioning Analysis.)

Sensible Heat Added

If the ratio line is like *1-5* or *1-3*, then, as has been stated, no reheating will be required under conditions of maximum load. However, as the sensible load drops and the ratio line swings over to a position like *1-2* of Fig. 11, the air must be reheated. The sensible heat added during reheating is exactly equal to the difference between the maximum sensible heat load for which the system was designed and the actual sensible heat load corresponding to the ratio line *1-2*. Consequently, in reheating systems the refrigerating equipment always operates at maximum capacity. Whether or not this will be a disadvantage depends upon the type of refrigerating equipment. If the equipment is such that the power consumption for operating it is reduced nearly in proportion to the load, then, of course, the refrigerating equipment for a reheating system becomes expensive to operate. On the other hand, if as is sometimes the case, the power required by the refrigerating equipment varies only slightly with the load, then the fact that the refrigerating equipment must be operated at practically full load at all times has little effect upon the operating cost.

All of the remarks in the foregoing paragraphs on the single duct system apply equally well to the double duct system. The cycle for the double duct system on the psychrometric chart differs only slightly from the cycle for the single duct system. Thus, the skeleton psychrometric chart of Fig. 12 illustrates the cycle for the double duct system of Fig. 10. All of the air is dehumidified down to point *3*. Part of the air is then reheated from point *3* to *5*. Chilled air in condition *3* and reheated air in condition *5* are then mixed to provide a mixture at point *4* along line *1-2*. As has been stated, the double duct system is a satisfactory type particularly for offices and industrial installations in spite of the fact that a duct system of practically twice the air delivery capacity of a single duct system is required.

The disadvantages of control by reheating are, of course, a greater first cost and a larger operating cost. The refrigerating equipment must be sized for individual peak loads in each room even though these occur at different hours. Because of reheating, the sensible load in any room is the sum of the actual sensible heat gain and the sensible heat added to the air by the reheating. During periods of peak load there is, of course, no reheating and the load in any given room is exactly the same as it would be without reheat.

In ordinary zone systems in which the control is by volume or bypassing, the refrigerating plant can be sized for the peak load at any hour instead of for the sum of the individual peak loads in each zone. Whether or not there would be a large difference in the refrigerating plants under the two systems depends upon the building. There is no general answer to this question.

A zoned system controlled either by reducing the air supply or by bypassing will result in a lower cost for the operation of the refrigerating plant. The reason for this is, of course, that when the volume of air that is dehumidified and chilled is reduced because of the reduction in sensible load, dehumidification by the refrigerating plant is also reduced. In other words, the relative humidity in the zoned spaces rises. The cost is lower only because the plant is doing less work—because it is not maintaining desirable relative humidities.

Reheating Cost Justified

This situation is exactly analogous to the often commonly noticed fact that it sometimes costs more to operate a new heating system that satisfactorily heats all parts of a building than it did to operate an old inefficient heating system that left many parts of the building chilly.

No system is being operated economically if economy is achieved at a sacrifice in results. For installations with steep ratio lines under maximum load conditions, the fact that the air must first be cooled in order to dehumidify it and then reheated appears superficially to be a wasteful process. It is a wasteful process if we consider that the only function of an air conditioning system is to maintain a given dry bulb temperature. However, if we consider the maintenance of a proper relative humidity at all times as an equally important function of the air conditioning system, then certainly cooling and reheating is not wasteful. The cooling must be done to obtain a given dew point; reheating to obtain a given dry bulb temperature. Certainly no one would consider that an air conditioning system should be designed only to maintain a given dry bulb temperature and that the humidity can be disregarded.

To operate an air conditioning system only to produce dry bulb temperatures while the humidity is allowed to rise to uncomfortable heights and to regard any extra refrigeration needed to reduce the relative humidity as wasteful is certainly an absurd viewpoint. Such a viewpoint is akin to that of a woman who wraps her ice in newspaper "so that it won't melt so fast." She has invested in a refrigerator and in ice, but she is not utilizing them to obtain desirable results. Similarly, an owner who is aware of the facts would certainly not regard cooling and reheating as uneconomical if he were aware that only in this way could desirable humidities and temperatures be obtained for his particular conditions.

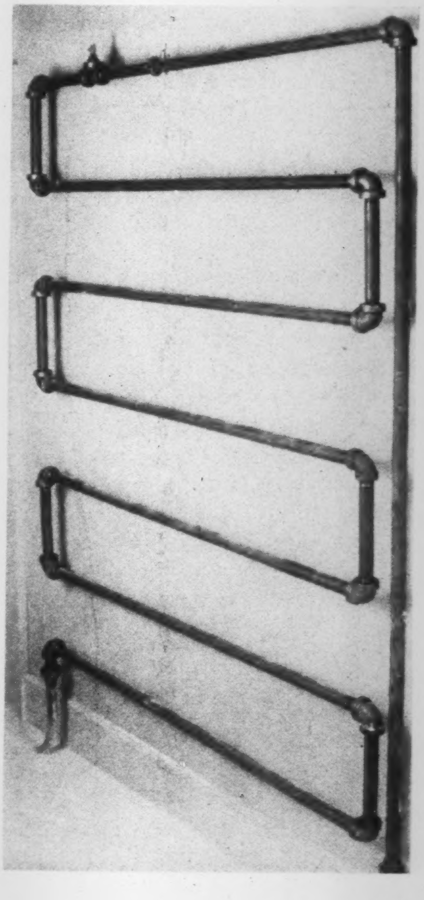
Because of our preoccupation with maximum load conditions, we forget that air conditioning systems operate most of the time at sensible loads that are less than the design maximum. Most of us think in terms of controlling only the dry bulb temperature, and of relative humidity as something incidental that will take care of itself. Under maximum load conditions, the humidity will take care of itself, but under light load conditions the clammy conditions produced make friends neither for air conditioning nor customers for the merchant who depends upon air conditioning as an attraction to bring people into his place of business.

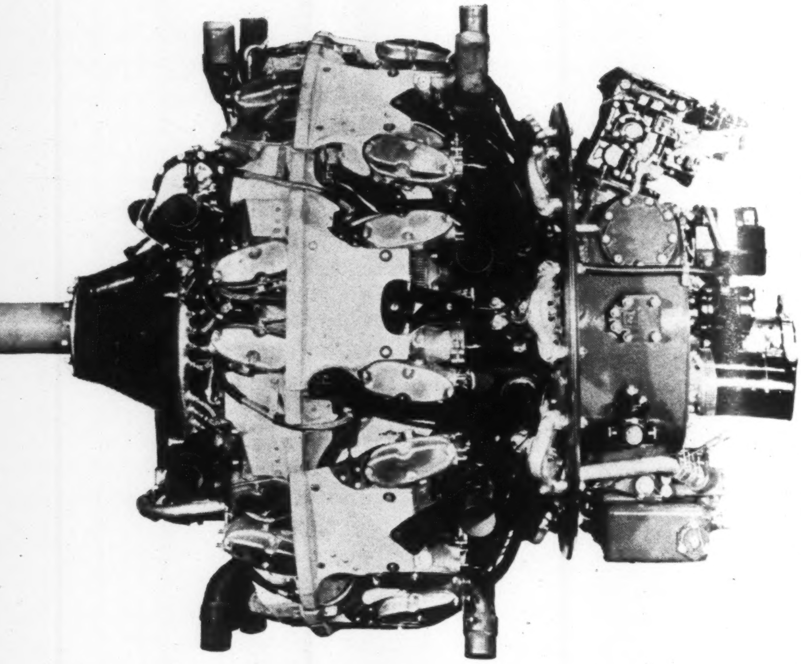
Because of our concern with dry bulb temperature control, it is a quite common attitude in the air conditioning industry to regard cooling followed by reheating as economically unsound. It is equally unsound to install an air conditioning system that is capable only of controlling the dry bulb temperature and then to obtain conditions much of the operating season that are unsatisfactory. If the air conditioning system produces both the desired relative humidity and dry bulb temperature, it is not wasteful. It is not wasteful even though the cost of such operation is greater than the cost of producing a clammy atmosphere. It costs more to keep a refrigerator at the proper temperature with bare ice than it does to keep a higher unsatisfactory temperature with ice swathed in newspapers.

DRYING RACK

Dr. C. E. Ward, of Durham, N. C., suggests this emergency drying rack, which has demonstrated its capability by drying complete racks full of clothes in from 10 to 20 min.

Hot water from the heating boiler is circulated through the ¾ in. wrought iron pipe coils by means of a 1 in. fuel lift pump. The pump can be turned on or off with a wall switch. The rack is positioned about 6 in. out from the wall and takes up very little room.





The practical application of heating, piping, and air conditioning principles is essential in providing the test facilities for airplane engines. Illustrated is the 18 cylinder, 2200 hp Wright engine used for the big new B-29 bomber

Heating, Piping, and Air Conditioning Involved in Testing Airplane Engines

F. O. Jordan, mechanical engineer, Albert Kahn Associated Architects and Engineers, Inc., gives a general picture here of the facilities required for testing airplane engines, shows that heating, piping, and air conditioning principles and their practical application are all involved. Miles of gasoline, oil, steam, water, and other piping services must be provided. Air must be supplied in tremendous quantities and in the proper conditions to cool the engines and to simulate actual wartime and peace operation.

TESTING AIRPLANE engines has turned out to be another job involving a practical working knowledge of heating, piping, and air conditioning. The equipment for absorbing the engine power; the apparatus for creating artificially the natural working environment of the "sky power plant"; the maze of ducts and piping for the air, oil, gasoline, heating, cooling, and other services; the labyrinths of controls, tubing, and wiring; the enclosing structures stout enough to restrain runaway forces when a good idea goes wrong—these and other items are involved.

For cooling the air cooled engine, air is forced by mechanical fans through the engine cowling. Both supply and exhaust fans are used, the total static of the fans being in the neighborhood of 40 in. of water to obtain the normal effect of the speed of the airplane plus the slip stream of the propeller when in flight. For the liquid cooled engine a tank, heat exchanger, and coolant circulating system is required. Air is supplied at considerable pressure to the carburetor by a separate supply blower to simulate the effect of the carburetor intake airscoop of an airplane in full flight. Various grades of gasoline and oil are supplied through suitable piping to the various engine test stands.

Engine testing falls into different categories. In the first place is the scientific research type of test setup with unique features such as air processing apparatus for maintaining stratospheric conditions, including —60 F temperature and 600 mph wind tunnels for aerodynamic research. Such installations are restricted to a very few and are supported by the government or by the pooled resources of a number of leading aeronautical concerns. Aerodynamic research in its most advanced and abstract form is conducted at such places.

Then we have the engineering test cell maintained by the individual airplane manufacturers where improvements and new designs are tried out. With the exception of having a more complete equipment of instruments and more kinds of gasoline and other service piping, these cells are little different from the production test cells which form the bulk of the engine test plants.

Production test cells probably get about 99 per cent of the work, for every engine off the production line has to be run-in and proved under its own power in a production test cell. Classified according to the method of absorbing the power developed by the engine during its test, test cells may be divided into dynamometer test cells, power recovery test cells, and the wind tunnel type of cell where the power is absorbed merely by placing a propeller on the engine. This propeller may be a standard flight propeller, or it may be a shortened propeller known as a "club."

In the case of the dynamometer test cell the engine drives a cradled dynamometer for measuring the power developed by the engine. The direct current generated by the dynamometer drives a d-c motor-a-c generator, which in turn delivers a-c power into the plant system. The dynamometer functions as a d-c motor for starting the engine and running it in, and is supplied with d-c power from the motor-generator set, acting as an a-c motor-operated d-c generator during this period. Thus, at least a portion of the power developed by the engine under test is delivered into the plant power distribution system to help carry the plant power load.

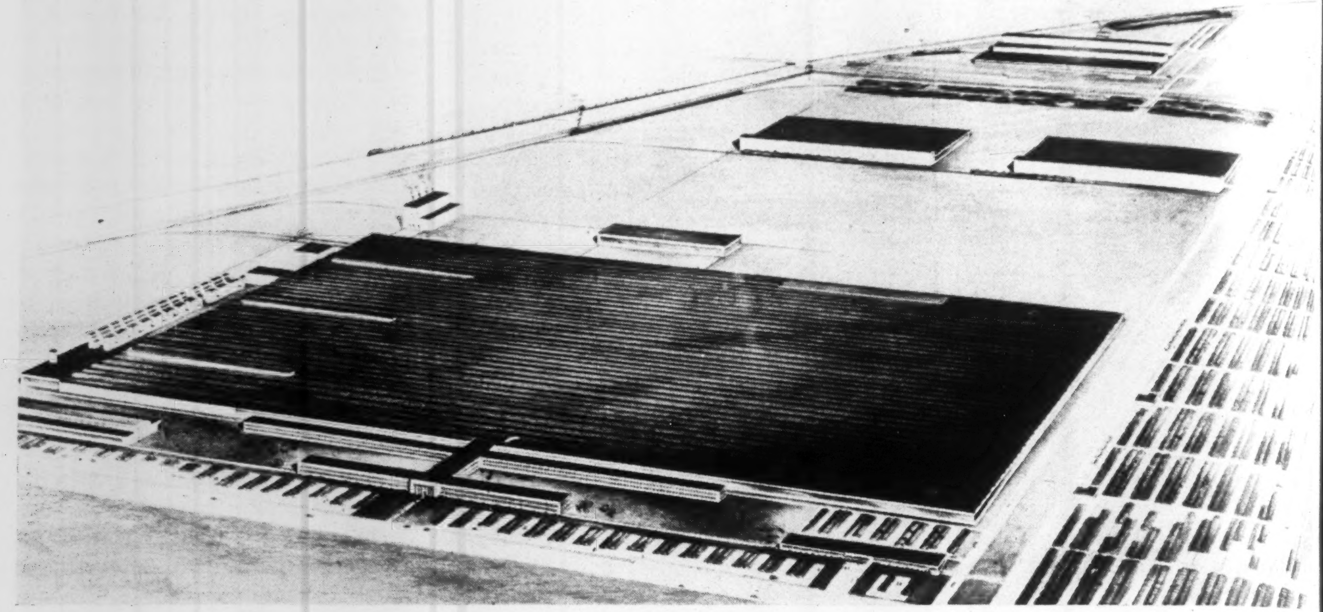
In the power recovery type of test cell, the airplane engines under test are connected to electric generators to generate power for use throughout the airplane engine manufacturing plant. The generators are installed in a long generator room and the engine test cells are arranged along the long side or sides of the room so the generators may be driven by the engines through drive shafts projecting through the wall. The test cells generally are arranged in pairs with a control room between them. During tests, attendants and engineers occupy the control rooms whence the engine is under visual observation through windows and under constant check by means of various instruments for indicating or recording engine performance. A passageway is provided along the ends of the test cells for use in transporting engines to and from the test cells.

In some instances, direct current generators have been used for loading the engines to avoid the necessity of synchronizing alternating current generators with the electrical system when the latter type of generator is installed. However, alternating equipment generally is employed, because of the almost universal practice of using this type of power throughout manufacturing plants. These generators are either synchronous type or wound rotor induction type. When synchronous generators are employed, they are connected to the engines through either water cooled hydraulic slip couplings or magnetic slip couplings or eddy current brakes. The generator is selected so that its synchronous speed is about the same as the minimum loading speed of the engine. When the engine is running at this synchronous speed, all of the power, less transmission losses, is transmitted to the generator. But when the engine is running at higher speeds, only a portion of its power is recovered as the increase in power recovery is not so great as the increase in power developed by the engine. When the engine is operating at lower than synchronous speed, none of its power can be recovered because the generator would merely act as a motor and help turn the engine. However, at such low speeds the engine can be loaded by holding the generator stationary when the magnetic slip coupling is used, as this mechanism will act as a brake.

With the slip coupling operated synchronous generator type of installation, the generator is unloaded until brought up to speed by making the coupling inoperative. After the generator is brought up to speed, the coupling is cut in and the generator operated as a synchronous motor for running-in and starting the engine. After the engine is running at or above synchronous speed, the generator is operated as a generator.

When the wound rotor type of generator is used, it is connected to the engine and variable speed control resistors are provided for controlling speed when the unit is operating as a motor before the engine is "fired" and for varying the loading when operating as a generator. After being connected to the engine, the electrical unit is

A service corridor for aircraft engine test cells, showing some of the many piping services overhead



Artist's rendition of the Dodge Chicago plant, division of Chrysler Corp., released by the Army air forces. The engine test cells are along the end of the large main building at the left of the picture

operated as a motor for running-in the engine and starting it. After the engine passes synchronous speed, it drives the electrical unit as a generator. With the wound rotor induction type of electrical generator, loading is provided for the engine over a wider range.

When propellers are used for loading airplane engines under test, the test cell is constructed in the form of an air passageway or tunnel through which the air is drawn by the propeller. Three different types of test cells are in use, the straight or "blow through" type and the "U" and "L" type cells. The blow through cell is merely a straight, tunnel-shaped passage through which the propeller draws the air in at one end and blows it out at the other. The "U" shaped cell consists of a horizontal tunnel with an intake tower at one end and an exhaust tower at the other end. The air is drawn downward through the intake tower, passed horizontally through the tunnel portion and blown upward out of the exhaust tower. In the "L" shaped cell, the air is drawn down through an intake tower and discharged out horizontally. The test cells are constructed in pairs with a control room between the test cells. Rooms for housing air circulating fans and air treating equipment are situated above and below the control rooms. A service corridor is provided along one end of the test cells for bringing in the engines for test and taking the tested ones away. Space is provided adjacent for inspecting, repairing and overhauling defective engines.

Even though the flight propeller draws a large volume of air through the test cell, additional air must be provided for cooling the engine. The inner ends of the propeller blades throw so little air around the cylinders of the engine that the engine will overheat if turned up for more than a few minutes while the airplane is standing still. The high velocity resulting from the speed of the airplane in flight is necessary to prevent overheating of the engine. Since the engine on the test stand has no forward motion, an air jet at very high velocity must be projected through the propeller by an annular nozzle against the engine cylinders. This air is supplied through a duct by a blower type fan operating against a very high static to simulate flight conditions.

Likewise, air must be supplied to the carburetor air intake at a pressure sufficient to simulate flight conditions for all types of test cells. This air generally is heated or cooled to some standard condition. The heating generally is accomplished by means of a steam heating surface, while cooling is done by heat exchange surfaces through which cold water is circulated. Similar heating and cooling units generally are provided for the control room air supply also. At some plants city water is circulated through the air cooling surfaces, while in others well water is used. In many of the test cell installations, refrigeration plants running into several hundred tons of refrigerating capacity are in use for cooling the water.

The gasoline handling equipment and distributing system at the typical airplane engine testing installation is a sizable plant within its own right. Some of the larger of the plants use in the neighborhood of a million gallons of gasoline in a two month period.

Gasoline handling systems at these plants consist of tank car unloading stations and pumps, miles and miles of gasoline mains, huge "tank farms," gasoline dispensing systems (which generally are of the water flotation type in which the gasoline is forced out of the tanks into the dispensing systems by pumping water into the tanks and the tanks are filled by pumping gasoline into them to force the water out), gasoline metering equipment, and the necessary connections to the carburetors.

The gasoline is heated by means of heat transfer surfaces or cooled by cold water heat transfer surfaces as required to maintain a certain standard gasoline temperature, and is fed to the carburetors through "constant head boxes" for maintaining a constant pressure at the carburetor. In some instances, gasoline dispensing pumps have been used instead of the water flotation method. Complete systems generally are provided for several grades of gasoline.

The oil handling systems are extensive affairs also, for a number of types of oil are required. There must be lubricating oil supply and return systems; systems of cleaning oils, with which the engines are flushed out for removing dirt, metallic particles, etc.; and flushing, or rust inhibiting oil. After the test runs are complete and the engine has been thoroughly cleaned, it is flushed out with a viscous oil which forms a protective coat for preventing corrosion during shipment and storage. The oil system includes the tank car unloading station and pumps, the oil mains and the tank farms where the oils are stored, the dispensing pumps and systems for taking the oil from the tank farm and supplying it to the engines in the test cells, the return oil systems for taking the used oil from the engines and returning it to the dirty oil storage tanks in the tank farm, and the pumps and piping for taking the dirty oil from the tank farm and loading it onto tank trucks and cars for transportation to the reclaiming station.

The handling of oils presents a problem not present with gasoline handling, as they will not flow very well when too cold. This means that steam coil heaters must be provided for tank cars and storage tanks and steam lines often are wrapped together with the oil mains for their entire lengths. Steam heating surfaces and water cooled surfaces generally are provided for maintaining a standard oil temperature supplied to the test cells.

The water quantities required by the test cells for power absorption and for cooling gasoline, oil, carburetor air, and the air to the control rooms are tremendous. In some instances there are three types of water: refrigerated water, well water, and city water. In some cases where the city water is cold enough for all types of cooling, there is some simplification of water services. Then there are the return systems for the water after it has been warmed by absorption of heat from the substances cooled. In some plants the warmed water is cooled for re-use, or is used for other purposes where cold water is not essential. In other plants the water is run to the sewer.

Other piping systems include the steam and return mains for the various gasoline, oil, and air heaters and for heating the building. The control rooms are heated by the air circulating units that are used for cooling in warm weather. The service corridors, repair rooms, and other portions of the buildings require heating also. Warm air circulating systems or units are provided for heating the test cells after test runs in cold weather so the mechanics may work in comfort between tests. In addition are the usual hot and cold water services, drainage systems, etc., for toilets and washrooms and general building usage. Drainage from work areas where contamination by gasoline and oil is likely must be put through oil separators for removing the gasoline and oils before they may be run to the sewage system. In fact, the quantity and complexity of the maze of piping systems required for the large engine test plants are staggering, involving hundreds of miles of mains buried underground, crowded together in long tunnels, and festooning the ceilings of the buildings.

Test Methods Not Uniform

The comparative newness of aviation as a great industry results in a noticeable lack of standardization and uniformity in engine test methods. For example, some experts swear by the power recovery type of test plant, while others say the saving in power is too small to justify the additional expense. An important argument against the power recovery idea at present is its extensive use of critical materials. Its protagonists point out that even more critical materials are required to make the electric power in a power plant and transmit it to the test plant. Of course, this argument does not hold if the local power plant and power transmission systems are already ample, which often is the case. The somewhat temporary nature of many of these huge war plants that have displaced so many perfectly good cornfields in the past few years must be considered when deciding on the equipment for them. But time will tell, for one of these days the war will end and the aviation industry will acclimate itself to the needs of peace and so allow its practices and procedures to crystallize.

Already, the construction and arrangement of the engine test buildings have become so well established they may be called conventional for that particular usage. The general arrangement of these buildings has been described already. The universal demand for something that disintegrating propellers and engines cannot go through calls for heavy, solid concrete construction with no windows. This type of construction also helps keep the noise levels within livable limits. As a further precaution against noise, a sort of eggcrate arrangement of sound absorbing materials is generally installed in the air outlet passageway of propeller test cells. On some of the recent installations, the openings to the test cells are provided with both inner and outer doors, the inner door being heavy, solid concrete and the outer door being steel. These doors are made as airtight as possible and a partial vacuum is maintained in the space between the doors by exhausting the air. This arrangement provides considerable protection against departing propeller tips, which are said to pass right on through mere steel doors, and materially reduces the terrific noise waves.

Even with the sturdy construction of the buildings, a walk down the long service corridor between batteries and batteries of test cells is an impressive thing. For the ceaseless vibration and thunder of thousands and thousands of horsepower on either hand is most convincing of the nearness of supercharged power, and you are thankful for the thickness of the intervening walls of solid concrete.

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Practical Pointers

on SCHOOL HEATING PLANT OPERATION & MAINTENANCE

From Scotty-Grams, a bulletin issued to operating personnel of the Chicago Board of Education by John Howatt, chief engineer, and member of HPAC's board of consulting and contributing editors

1. Proper furnace baffling is important. If the boiler furnaces in your plant need repairs or changes that will promote better combustion, the work should be done after receiving official approval. Experimental changes in furnace design or baffling should not be made without having them first approved by the chief engineer.

2. Make daily check on blowoff valves, steam traps, bypass valves, and drips to be sure no steam is escaping.

3. Leaky blowdown cocks may be due to an accumulation of mud and scale under the plug cocks. Cleaning of them will prevent many replacements and heat waste.

4. The use of the flue gas analyzer is proving of great help in obtaining better combustion. These instruments when used regularly in our school buildings help to further the cause of fuel conservation. However, they must be used and the story they tell followed in directing operating practices if they are to have value.

5. Dirty air filters may cause improper heating and ventilating by shutting off the air supply. Check frequently by observation and by testing the air pressure drop through them.

6. If difficulty is experienced in warming any room heated by air, make a test of the air volume being delivered. If air volume is small, make a thorough examination of the duct from plenum chamber to room outlet to make sure no obstruction exists. Take nothing for granted.

7. Test thermometers for accuracy. Line up all thermometers in a room undisturbed by air movement. The thermometers which are "off" will soon be evident. Clean the scale indicators and cover brass with white varnish to prevent oxidation.

8. Maintain a thorough examination of all belts, set screws, shaft, safety catch, and valve rods on engine governors. Test the operation of this equipment by simulating accidents, but be sure to have the throttle valve well under control before attempting a test of this kind. A runaway engine can cause $1000 damage in less than 30 seconds. Take nothing for granted.

9. Constant boiler feed is preferred over start and stop boiler feed when boiler loads are heavy enough to permit such method of water line regulation.

10. Do not feed cold water to a boiler merely to avoid blowing the safety valve. A fuel loss will occur whether the valve pops or if cold water is added. Safety valves should not pop oftener than once a day, but if unavoidable increase in steam occurs, let them pop. This will avoid a strain on the boiler due to the use of cold water.

11. Steam line valves to soot blowers should always be tightly closed. Leakage through these valves causes acid formation and promotes serious corrosion of boiler tubes. For the same reason the line must be blown dry and hot through the drip before opening the valve permitting steam to the nozzles.

12. Constant vigilance must be exercised in looking for and preventing air infiltration through brick furnace settings. Leaks are often hard to locate but it must be remembered they most likely exist, for a boiler furnace is under subatmospheric pressure, so is subject to infiltration through the setting.

13. Caulking around the base and under water legs of steel firebox boilers eliminates a loss from uncontrolled air infiltration. This type of boiler furnace is tight everywhere else.

14. Hand lancing of shipping board type water tube boilers will have the best results when a pipe curved at the end is used making it possible to direct the jet of steam between the tubes for effective action.

15. When blowing down a boiler the inside valve should be opened first and then the Y valve. In closing, reverse this procedure.

16. During periods of mild weather it is advisable to begin the checkup of the entire heating system equipment, making written notes of repairs needed where those repairs cannot be made during periods of operation.

Opposed to Metric System

THE BUGBEAR of the metric system rises again on page 88 of the February HPAC, and following issues. Only a small number of the peoples of the world use the metric system—a system based on inaccuracies. During the first great war those nations who used the metric system and placed orders with the English speaking peoples of the world found that it hampered the start of production. The quantity of numbers (figures) required for dimensions in the metric system is proof that it does not work in practice. Hence, I am very much opposed to the metric system.—J. C. STAVELEY LAWSON, consulting professional engineer.

How the Army Saves Fuel

Education Programs, Control Devices, Other Means Cut Consumption from 5 to 15 Per Cent, Says C. E. Miller, Repairs and Utilities Branch, Office of the Chief of Engineers . . . Annual Expenditure for Fuels by the Army Is Approximately $100,000,000

NO DISCUSSION of the fuel conservation program, as it applies to the Army within the continental United States, would be understandable without some knowledge of the organization under which it operates. The three component parts of the Army under the Chief of Staff are the Air Forces, Ground Forces, and Service Forces. The job of the Service Forces is to feed, house, clothe, pay, equip and transport the Army. The Chiefs of Engineers, Ordnance, Transportation, Chemical Warfare, Chaplains, The Quartermaster General, and the Adjutant General direct these various services as staff members of the Commanding General, Army Service Forces. The Corps of Engineers has the responsibility of building and maintaining all the posts, camps, and stations and providing them with utilities.

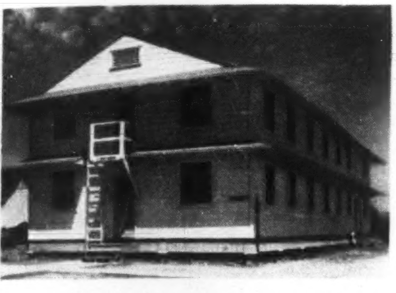

Fig. 1—Typical cantonment construction heated by warm air systems

For the performance of these functions the continental United States is divided into nine Service Commands, each under the jurisdiction of a General Officer who is the representative of the Commanding General, Army Service Forces. His staff likewise is composed of representatives of all the services.

The general planning and supervision of the army fuel conservation program is the responsibility of the Chief of Engineers. At the Service Command level the Service Command Engineer coordinates the program and is responsible for its direction at individual Army posts. There are two classes of engineers on the staff of the Director specifically charged with the field activities pertaining to this program. The "Fuel Service Engineers" are responsible for insuring an adequate, but not excessive, supply of fuel, and supervision of all fuel storage and handling. The "Combustion or Heating Engineers" coordinate the program as it affects operation of the heating equipment and economical utilization of the heat after it is generated.

On the Army posts themselves the utility work is the specific responsibility of the Post Engineer under the supervision of his Commanding Officer. The Post Engineer, through his Mechanical Engineer, usually divides his activities relating to fuel conservation into three categories: (1) fuel handling and distribution, (2) operation and maintenance of the larger heating plants, which is entirely a civilian organization, and (3) operation and maintenance of the small heating plants. These small plants are normally operated by soldiers, but supervised and maintained by a civilian organization of heating mechanics.

Types of Plants and Fuel Used—For the purpose of operation, the Army heating plants are divided into two classes. Those having a capacity of less than 100 hp are designated as "domestic heating plants" and are generally fired by the soldiers themselves, while those of over 100 hp are called "central plants" and are operated by civilians. A typical building heated by the first class of installation is shown in Fig. 1; this general class of construction is known as the cantonment type, and most of the buildings at Army posts are of this type. There are approximately 150,000 domestic heating plants in such buildings, of which one-half are warm air furnaces and the remainder steam or hot water boilers and direct fired unit heaters. The other general class of construction is designated as theatre of operations type. These buildings are heated by something over 400,000 space heaters, most of which are coal fired. In addition to the above, there are approximately 100,000 water heaters and 80,000 mess hall ranges classed as domestic heating equipment.

Typical central plant installations are shown in Figs. 2 to 6. Fig. 2 is an exterior view of a typical hospital plant. The building proper is corrugated sheet iron (note the camouflage), with a covered coal storage provided at the left side of the building. In general the building has been reduced to bare essentials. Fig. 3 is an interior view of a typical plant showing the boiler fronts and the conveyor for lifting coal from the adjacent ground level storage to the stoker hoppers. Fig. 4 is another view of one type of coal storage bin; a ramp is provided elevating the trucks to the height required for the dumping operation. Fig. 5 shows the main hot water heating tanks, feedwater pumps, heaters, and storage tanks in a typical laundry boiler plant. The central plants total over 1300 in number and have an installed capacity of over 500,-

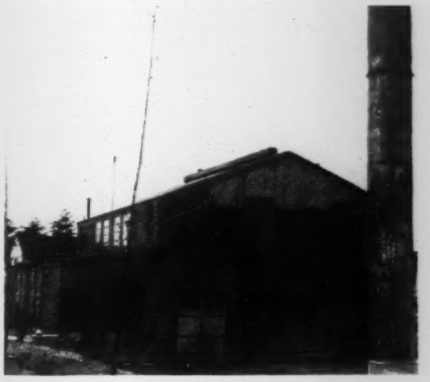

Fig. 2—Typical hospital heating plant

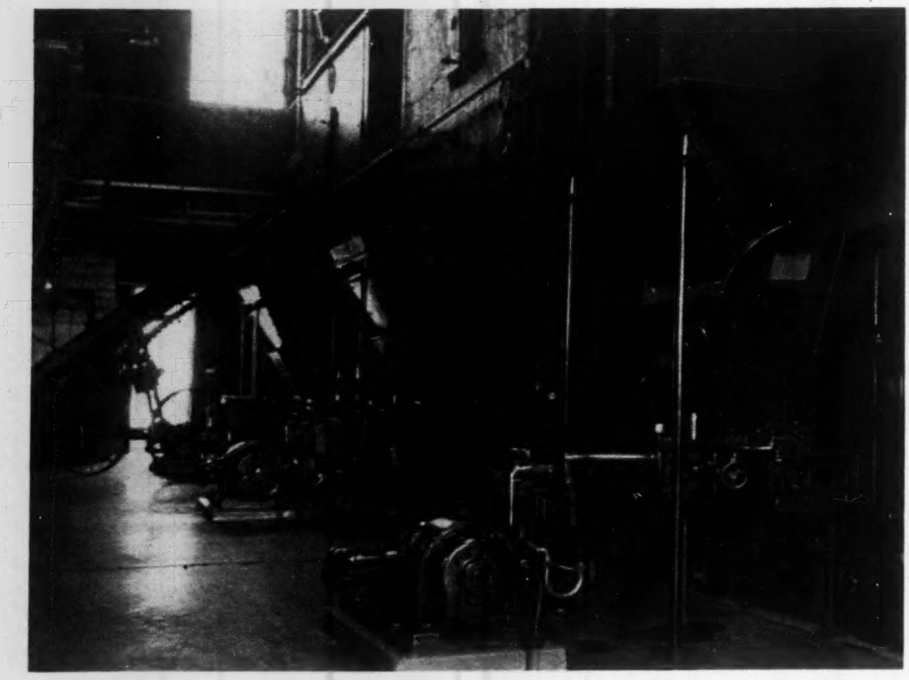

Fig. 3—Interior view of typical hospital plant. (Note conveyor for elevating coal from adjacent ground level storage to the stoker hoppers)

000 hp. As would be expected, in a program designed and constructed in such a short time, the equipment in these plants is of every conceivable type and manufacture; the photographs are intended to show only the usual arrangement and class of construction.

Most of the discussion on fuel conservation is concerned with coal. The problems relating to gas and oil fuel are relatively much simpler because the equipment using these fuels operates automatically. The Army uses all grades of coal, ranging from the higher grades of bituminous and anthracite in the east to very low grade, sub-bituminous fuels. Some grades almost approach that reported at a recent meeting: An Officer, in discussing some of his operating difficulties was asked if he had had an analysis made of the coal. His answer was, "Yes, sir, it was analyzed 40 per cent moisture, 40 per cent ash, and 20 per cent foreign material." This may have been a slight exaggeration, but it does serve to emphasize the fact that the handling and proper utilization of fuel in the Army must be planned to meet a wide range of conditions from the standpoint of both fuel and combustion equipment. Local conditions, type of fuel, climate, and type of equipment must all be taken into consideration in providing the best means of conservation. It is of interest to note that in the matter of degree days alone camps vary from 0 to over 12,000 per year.

Fuel Handling—The first steps in the conservation of fuel are to insure an adequate supply and proper handling. The Fuel Service Engineers of the Service Commands, in conjunction with the post personnel, are responsible for this part of the program. Complete records are maintained at each post to maintain continuity of supply for normal consumption, plus a reserve for emergencies. The quantity of coal requisitioned by any individual post is based on its degree days and floor area. Specifications for the type of coal to be used in each class of equipment are prepared in the Office of the Chief of Engineers. It is obvious that the first source of any waste is the acceptance of coal which is not suitable for the equipment on which it is to be used. As the specifications used in purchase cover only the minimum acceptable quality, all coal not meeting the specifications must be rejected.

Figs. 6 and 7 show typical coal handling equipment at an Army post. The slogan, "Coal Is Ammunition, Do Not Waste It," is kept before the eyes of the coal handling crews continually and is one means of stressing the importance of fuel conservation. Fig. 6 also illustrates some of the mechanical means of insuring minimum loss. For example, drag conveyors are used for unloading cars and loading trucks. This reduces the manpower required for handling coal and also reduces degradation of the lump sizes. The coal storage area has been stabilized to reduce loss from mixing with foreign material. Deliveries are scheduled as far as possible to reduce manpower requirements. Recently considerable savings in deliveries have been effected by changing from the original wooden coal box to a so-called "quick delivery" coal bin at the barracks. This quick delivery bin consists of a concrete pad approximately 10 ft x 10 ft on which trucks can dump directly, thus eliminating all hand shoveling. The problem of emphasizing the importance of fuel conservation to all firemen and coal handlers is a continuous one. Conservation posters are tacked to all coal bins and other coal storage facilities.

Educational Methods—If there is one single factor on which the success or failure of the Army fuel conservation program depends, it undoubtedly is that of a proper educational program. In domestic heating plants alone there are approximately 100,000 soldiers assigned to firing duty. Of this number, probably 5 per cent have never been assigned to such duty previously. Considering that soldiers' barracks are scattered from the sub-tropical south to the arctic north and that many of the men assigned as firemen have never seen coal or coal burning appliances before, the magnitude of this part of the educational program can be appreciated. Many stories are told regarding some of the soldiers' first assignments to firing duty before a regular program for their instruction had been instituted. The following is typical: It seems that a soldier was preparing to start a fire in an Army stove. He carefully filled the stove completely with fresh coal, then lit a match and threw it on top of the fuel, slammed the firing door shut, and jumped back, awaiting the coal to burst into a glowing flame.

The Army knows—perhaps better than anyone else—that fuels are ammunition and must not be wasted, and Mr. Miller describes here the Army's fuel conservation program which has resulted in "cutting down of fuel consumption by from 5 to 15 per cent." Because of the nature of its installations, and the personnel operating the equipment, the Army has particularly difficult fuel conservation problems not encountered in industry or private business. Many of the Army methods of fuel conservation can be applied profitably in plants and buildings, particularly the emphasis given to education on fuel handling and firing, it would seem.

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The education of soldier firemen in the proper performance of their duties is operated as a joint program of the Service Command combustion engineers and the post personnel, particularly the post heating mechanics. It is a basic policy that no soldier should be allowed to fire heating equipment unless he has had previous instruction. This instruction is conducted in a number of ways. One method is by use of a film strip which has been prepared on the proper firing of the various types of equipment including warm air furnaces, hot water heaters, boilers and space heaters. In many posts, the soldiers are brought together in large groups and taught by means of these pictures which illustrate proper and improper operation and the general principles of the heating system. In other cases, the heating mechanics bring the soldiers together in small groups and instruct them at the equipment itself. Small groups are sometimes instructed by means of colored charts which show the various parts of the equipment and their function.

For the purpose of insuring a continuous follow up on the maintenance and operation of this domestic heating equipment, all buildings on each post are divided into groups of approximately 50 to 100. To each one of these groups there is assigned a civilian heating mechanic whose responsibility it is to instruct the soldiers individually or in group meetings, to check regularly all of the heating equipment mechanically, and maintain it in good operating condition. This plan of employing heating mechanics has been remarkably successful since its inception in reducing maintenance and repair costs. At one post for example, the mechanics reduced maintenance costs from $3460 for the first half of the heating season two years ago to $150 for the same period last year. This same report estimated an annual fuel saving of $45,000. To keep the soldiers continuously conscious of fuel conservation, instruction charts have been prepared and are posted adjacent to the equipment. Figs. 8 and 9 are typical of such charts. Fig. 8 is that used in conjunction with the forced circulation warm air plants, using bituminous coal. Fig. 9 explains the operation of the U. S. Army No. 1 magazine type space heater as used in barracks, mess halls, day rooms, and orderly rooms. These posters are tacked or attached securely as near as practicable to the heating unit.

In order to coordinate the work of the heating mechanics themselves, schools are held for their particular benefit about every six months. These schools are usually under the supervision of the Service Command combustion engineer. At the session held in the fall of the year, problems relating to the operation of the equipment, the education of the soldiers, and specific operating procedures are discussed. At the spring meeting the rehabilitation and summer maintenance program is stressed.

The central plants are more varied in size and type than the smaller plants. The boilers in these plants are generally of the locomotive firebox type in sizes up to 300 hp capacity and of the water tube type above that capacity. Firing equipment includes practically every known make and type. Stokers, for example, include small screw feed, dead plate machines, larger sized ram feed, side dump units, chain grates, multiple retort underfeeds, and spreader stokers on boilers ranging up to 100,000 lb per hr capacity. There is also a limited amount of pulverized coal equipment.

As the civilian operating personnel in these plants is relatively permanent, and the plants themselves are not similar in detail, educational practices in fuel conservation generally follow two plans. First, the field combustion engineer, acting in his capacity as a service engineer, works in the plant with the operators in improving practices and overcoming difficulties. Second, group discussions by the plant supervisors are held at universities, or one of the larger posts, for periods of three days to a week. At such meetings discussions are conducted on general operating and

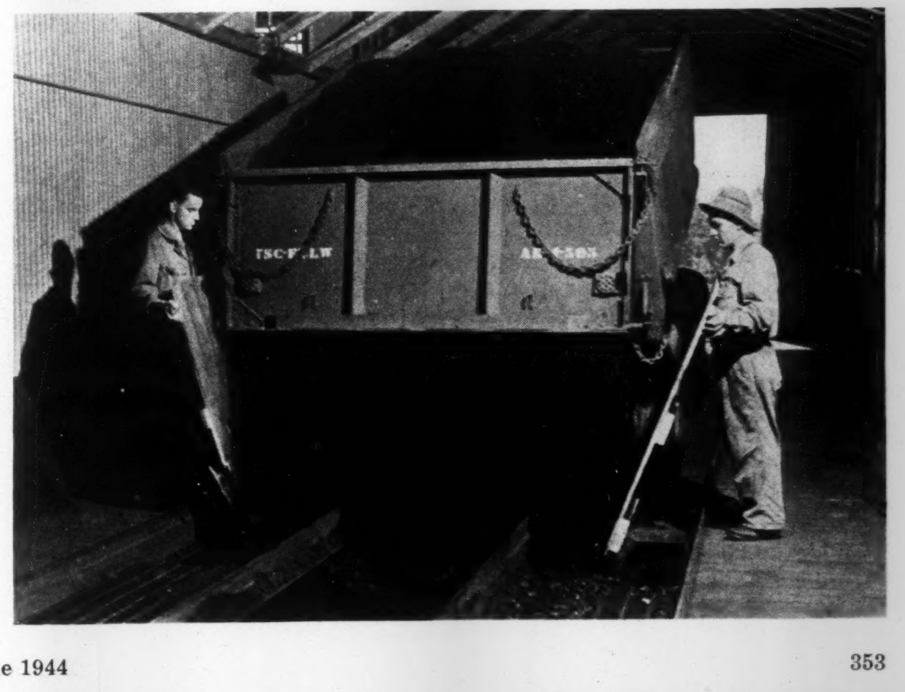


Fig. 4—Typical coal storage and handling facilities at hospital heating plant

maintenance practices and methods of improving operation of a general nature so that the information can be applied to all of the posts represented by the men in attendance. They include such things as use of a gas analyzer, principles of combustion, use of the boiler water test kit, and maintenance and use of plant records.

It has been found that a major factor in the success of an education program depends first on presenting the information visually by charts, films, and in some cases actual models; second, that the information be of a practical and not theoretical nature and that a close system of follow up on the operation of every piece of heating equipment be established through proper organization.

Fuel Saving Equipment—The conservation of heat after it has been generated has been found to be equally, if not more, important in reducing fuel consumption, as savings effected through the proper operation of the equipment itself. For example, the setting of thermostats in all buildings is checked regularly to insure adequate but not excessive temperatures. The opening of windows without banking fires is prohibited. At one post it was found that a device costing 20 cents applied to a room thermostat in such a way as to make it impossible to adjust the temperature over 70 F effected a saving of from 20 per cent to 80 per cent of the fuel. Time clocks used with automatic firing equipment have been found most effective and are approved for installation on all automatic firing equipment.

The use of automatic space temperature control equipment in certain heating systems has been found essential to efficient operation. Such equipment has been found particularly valuable in hospital areas and tests indicate a minimum saving of 15 per cent of fuel in such buildings where no other control has been previously provided. At the present time, these buildings are controlled by two general methods. In buildings where a representative location can be found for a room thermostat, this type of control is used and operates the steam control valve directly. In other types of buildings where a representative location cannot be found for a thermostat, an outside type of temperature control is used. In general, these outside type controllers are used to control from three to four buildings so their cost of installation is not much higher than that of the

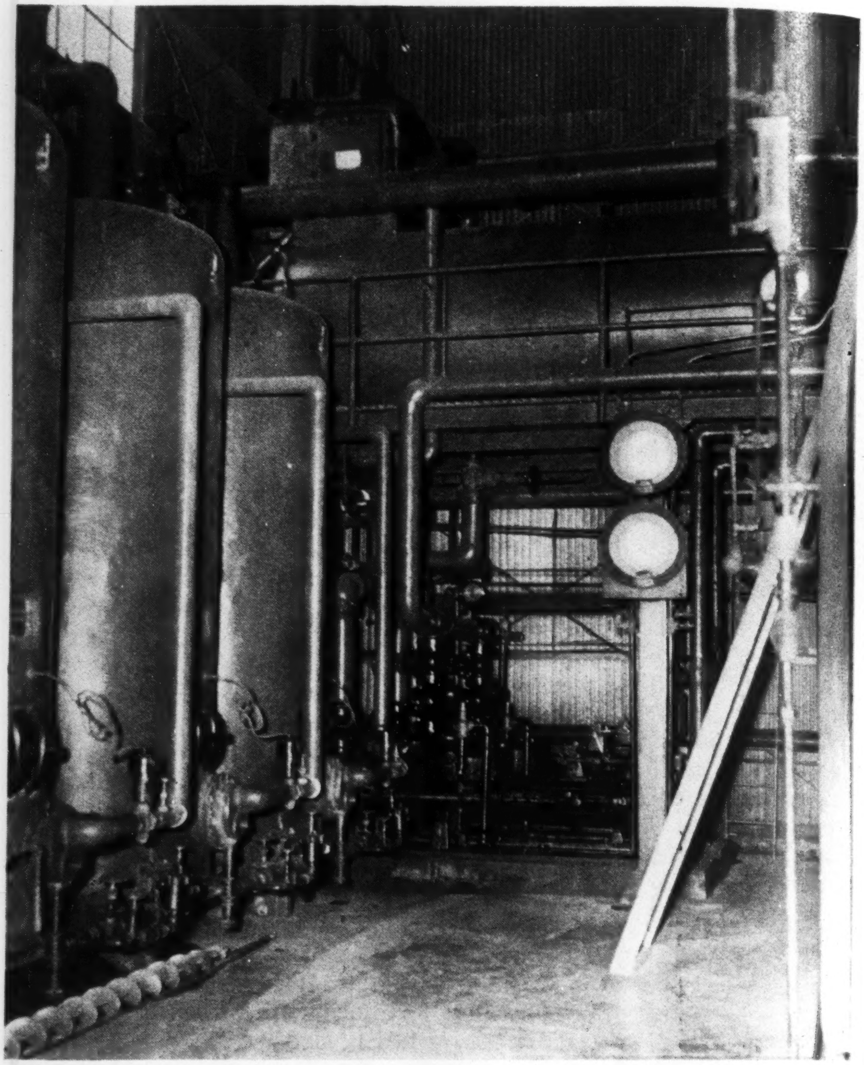


Fig. 5—Interior view of typical laundry boiler plant showing hot water heating tanks, feedwater pumps, heaters, and boiler feed storage tanks

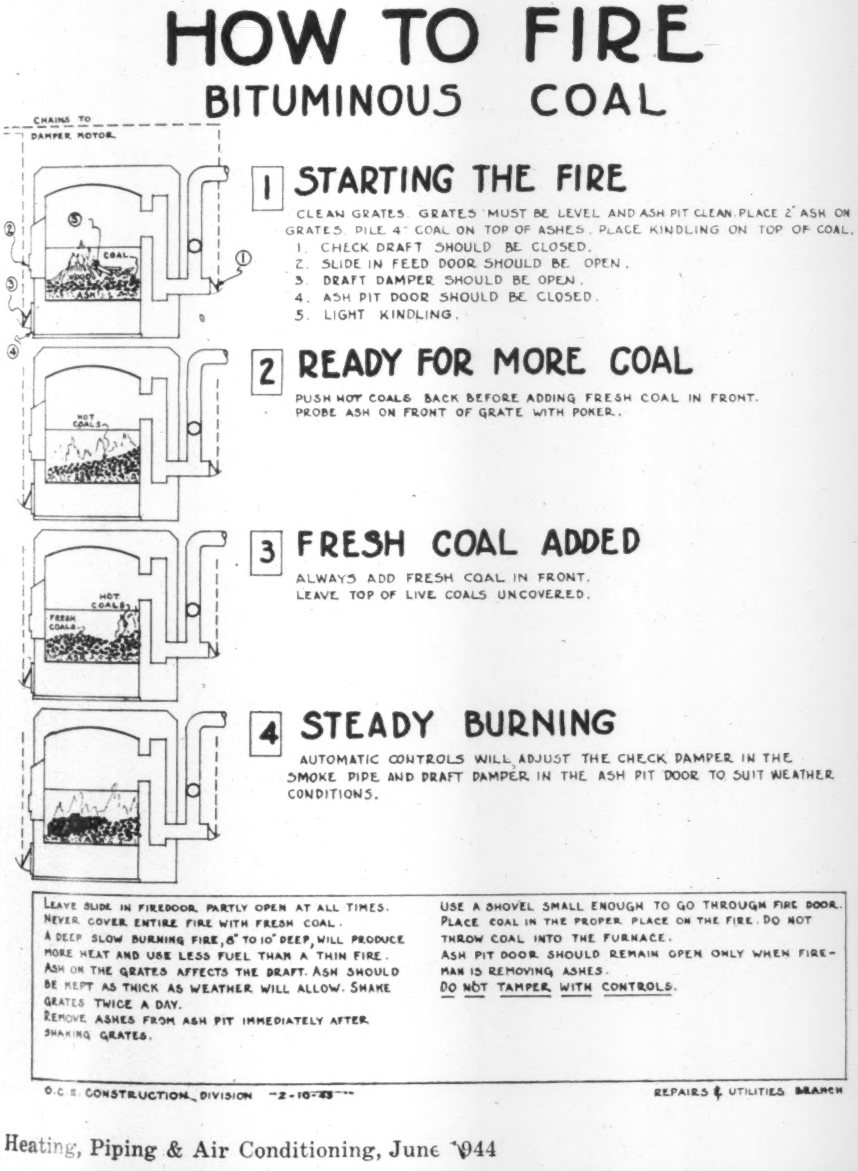
COAL IS AMMUNITION
DO NOT WASTE IT

Fig. 6—Typical coal handling equipment at Army post. (Note emphasis placed on coal conservation program)

COAL IS AMMUNITION
DO NOT WASTE IT

Fig 7—Another means of stressing the importance of coal conservation

Fig. 8—Instruction chart used in conjunction with forced warm air system



HOW TO FIRE
BITUMINOUS COAL

1 STARTING THE FIRE

CLEAN GRATES. GRATES MUST BE LEVEL AND ASH PIT CLEAN. PLACE 2" ASH ON GRATES. PILE 4" COAL ON TOP OF ASHES. PLACE KINDLING ON TOP OF COAL.

1. CHECK DRAFT SHOULD BE CLOSED.
2. SLIDE IN FEED DOOR SHOULD BE OPEN.
3. DRAFT DAMPER SHOULD BE OPEN.
4. ASH PIT DOOR SHOULD BE CLOSED.
5. LIGHT KINDLING.

2 READY FOR MORE COAL

PUSH HOT COALS BACK BEFORE ADDING FRESH COAL IN FRONT.
PROBE ASH ON FRONT OF GRATE WITH POKER.

3 FRESH COAL ADDED

ALWAYS ADD FRESH COAL IN FRONT.
LEAVE TOP OF LIVE COALS UNCOVERED.

4 STEADY BURNING

AUTOMATIC CONTROLS WILL ADJUST THE CHECK DAMPER IN THE SMOKE PIPE AND DRAFT DAMPER IN THE ASH PIT DOOR TO SUIT WEATHER CONDITIONS.

LEAVE SLIDE IN FIREDOOR PARTLY OPEN AT ALL TIMES.
NEVER COVER ENTIRE FIRE WITH FRESH COAL.
A DEEP SLOW BURNING FIRE, 8" TO 10" DEEP, WILL PRODUCE MORE HEAT AND USE LESS FUEL THAN A THIN FIRE.
ASH ON THE GRATES AFFECTS THE DRAFT. ASH SHOULD BE KEPT AS THICK AS WEATHER WILL ALLOW. SHAKE GRATES TWICE A DAY.
REMOVE ASHES FROM ASH PIT IMMEDIATELY AFTER SHAKING GRATES.

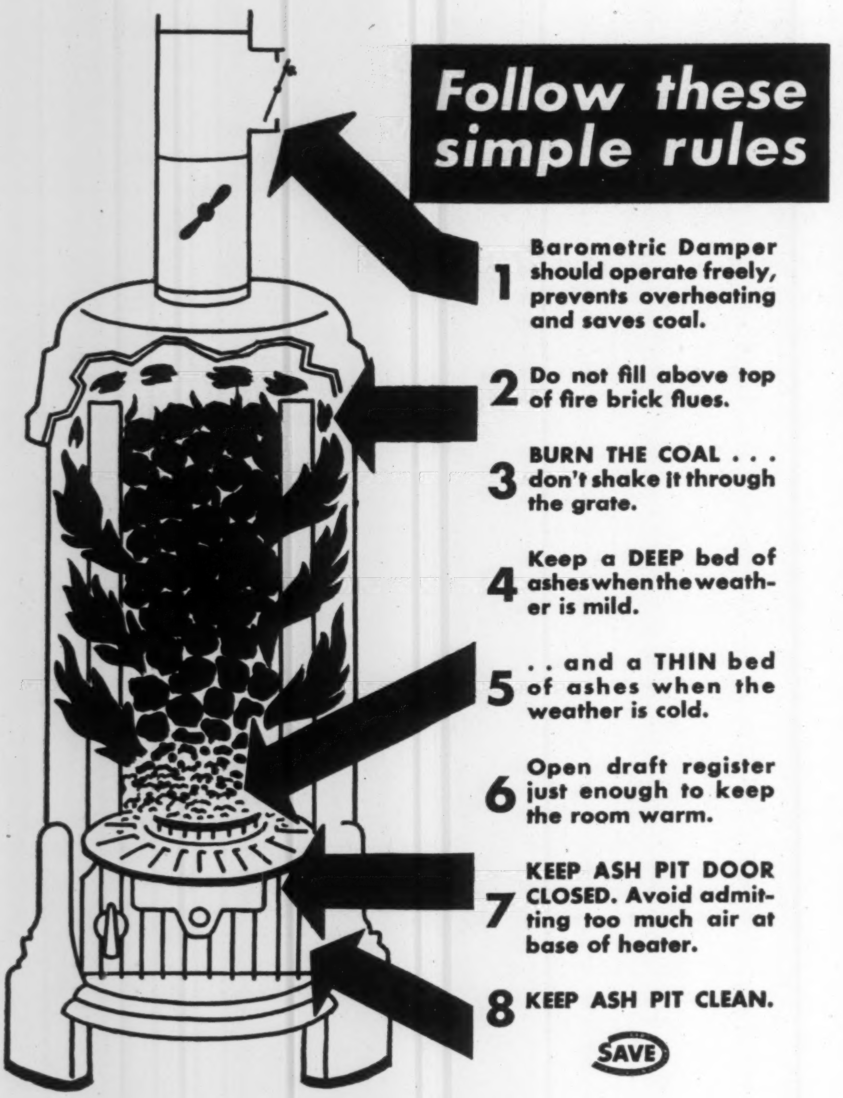
USE A SHOVEL SMALL ENOUGH TO GO THROUGH FIRE DOOR.
PLACE COAL IN THE PROPER PLACE ON THE FIRE. DO NOT THROW COAL INTO THE FURNACE.
ASH PIT DOOR SHOULD REMAIN OPEN ONLY WHEN FIREMAN IS REMOVING ASHES.
DO NOT TAMPER WITH CONTROLS.

O.C.E. CONSTRUCTION DIVISION -2-10-43-- REPAIRS & UTILITIES BRANCH

simple thermostat control method.

Instruments and control have been found essential to proper operation and necessary to the fuel conservation program. In central boiler plants it is the policy to provide steam flow meters and CO_2 recorders on boilers of 300 hp capacity and larger. Steam flow-air flow records are used in lieu of this combination. Automatic draft controls are authorized for all boilers of 150 hp and larger and draft gages are authorized for all boilers of over 100 hp capacity. All Army posts are expected to have at least one hand CO_2 analyzer. A typical instrument panel in one of the central heating plants is shown in Fig. 10. However, the use of such equipment is not the final answer in many cases. The educational program must be continuously maintained to insure the proper utilization of this equipment. Such conditions as existed at one post down in the pine country of Georgia must be avoided at all costs. At this post it seems that all of the controls had been installed in the hospital boiler plant but the operating engineer, who had previously fired a sawmill boiler, was still having difficulties. He came to the Post Engineer and wanted approval to make some changes in the installation to get away from his troubles. His solution was to pull out the stoker, remove the control instruments, install grates, and fire the 450 hp boiler with slab wood and sawdust.

Assistance Rendered by Outside Agencies—The Chief of Engineers, the Service Command Engineer, and the Post Engineer all have trained personnel qualified to carry on the activities of their echelon. The magnitude of the program and the shortage of manpower precludes the employing of the personnel required on all occasions. Supplementing the Army in this effort are a number of private and government agencies which devote considerable time to the heating problems of the Army camps. Anthracite Industries, Inc., was the first in the field and provided some 15 engineers who conduct schools in proper firing in the northeastern posts where anthracite is the fuel commonly used. This assistance is continuous and has materially reduced the operat-



Follow these simple rules

1 Barometric Damper should operate freely, prevents overheating and saves coal.

2 Do not fill above top of fire brick flues.

3 BURN THE COAL . . . don't shake it through the grate.

4 Keep a DEEP bed of ashes when the weather is mild.

5 . . and a THIN bed of ashes when the weather is cold.

6 Open draft register just enough to keep the room warm.

7 KEEP ASH PIT DOOR CLOSED. Avoid admitting too much air at base of heater.

8 KEEP ASH PIT CLEAN.

Fig. 9—Combination conservation and operating poster for space heater

ing costs of anthracite burning equipment.

Bituminous Coal Research, Inc., has likewise made available to the Service Command Engineers, some 70 combustion engineers of national reputation who are able to devote considerable time to conferences, schools, inspection, and trouble calls at Army posts.

In order to reduce gas consumption at posts, camps, and stations, the service of local gas utilities has been used extensively. These engineers have assisted in checking the adequacy of the post distribution facilities, the necessity for future looping of systems to decrease pressure drop, and the material requirements necessary for sectionalizing distribution facilities to repair leaks in mains.

All of these agencies have assisted generally in improving operation and maintenance practices. They have cooperated in checking the operation of the fuel consuming equipment itself, including regulators, controls, and fuel burning apparatus, made flue gas analyses on large installations, and rendered all possible assistance in adjusting equipment for effective fuel conservation.

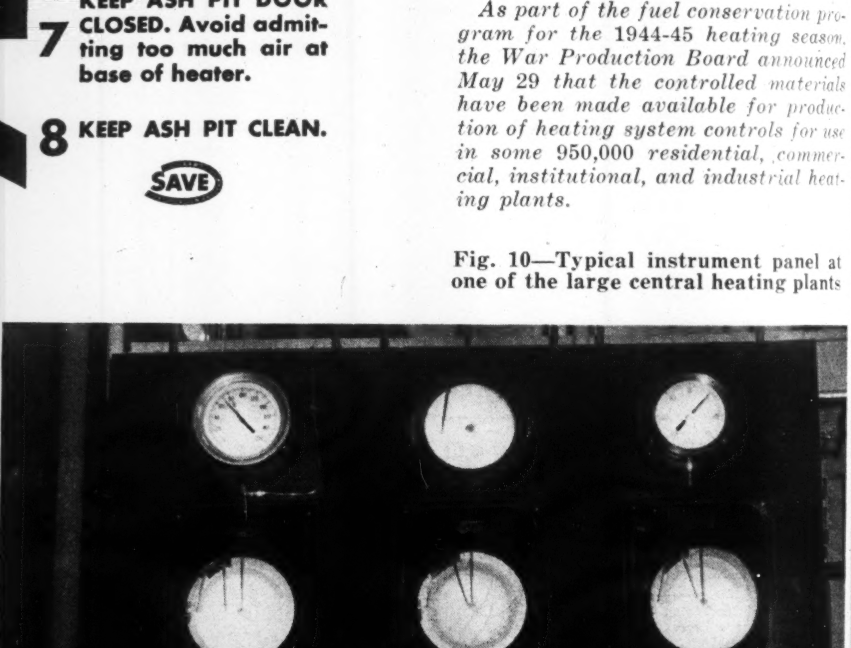
Cutting down of fuel consumption by from 5 to 15 per cent, as has been effected by the education programs, control devices, and other means described, may not seem a great achievement. The significance is apparent, however, when it is realized that in 1944 the Army will spend 70 million dollars for coal, 25 million dollars for gas, and 5 million dollars for fuel oil, wood, and miscellaneous fuels, or a total expenditure of approximately 100 million dollars.

* * *

HEATING CONTROLS PRODUCTION ANNOUNCED

As part of the fuel conservation program for the 1944-45 *heating season, the War Production Board announced May* 29 *that the controlled materials have been made available for production of heating system controls for use in some* 950,000 *residential, commercial, institutional, and industrial heating plants.*

Fig. 10—Typical instrument panel at **one of the large central heating** plants



"Open for Discussion"

Measuring the Moisture Content of Air

HPAC's readers and editors will welcome your comment on articles published in these pages, and on other topics of interest . . . Address Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2.

IF IT is not too late to comment on the question about measuring the moisture content of air published on page 75 of the February HPAC, I would like to offer a solution somewhat different than those printed.

The question relates to the determination of the total moisture in air, a portion of this moisture being free. It is not clear as to whether the questioner also desires to determine the initial state of the air, including the amount of free moisture.

If, after heating the air sufficiently to completely evaporate all moisture, the wet and dry bulb temperatures are observed, the psychrometric chart will establish the absolute humidity.

If the initial air were saturated and its dry bulb temperature is known, and the absolute humidity line, as determined after heating, and the initial temperature line are extended into the fog area, their intersection will give the initial condition of the air.

From the form of the inquiry, it is possible that the questioner had in mind free droplets of moisture in unsaturated air. In this case, the solution is not so simple, as this is not truly a psychrometric chart condition. It is necessary in this case to determine the rate of flow of air through the heater and the rate of supply of heat. The latter is very easily done by using a watthour meter in connection with electric heat. The former is not an unusual engineering problem. The heat added is then reduced to Btu per lb of dry air. Subtract this heat quantity from the enthalpy of the air in its heated state. Had the initial air been saturated, this new enthalpy should pass through the intersection of the initial temperature and moisture lines. If the initial air were unsaturated, however, this heat quantity must include some latent heat for the evaporation of sufficient moisture to saturate the original air. The new enthalpy, therefore, if the initial air were not saturated, will be lower than the enthalpy at the above-mentioned intersection in the fog area.

Perhaps this could be better stated algebraically. If h_1 is the enthalpy of the heated air, h_2 the enthalpy corresponding to the intersection of the absolute humidity line and initial temperature line, and h_3 is the enthalpy as found by experiment, then h_2 will be greater than h_3.

To locate the condition of the unsaturated initial air on the psychrometric chart, measure the difference h_2 minus h_3. Subtract this heat from the enthalpy of saturated air at the initial temperature. The intersection of this enthalpy line and the initial temperature line will give the condition of the unsaturated air provided the initial droplets were at air temperature. If, as would be more likely, the temperature of these droplets is lower than the temperature of the air, the actual initial condition of the air is indeterminate unless the temperature of the droplets could by some means be determined.

The Mollier form of chart is now generally used, and may be referred to in the ASHVE's Heating, Ventilating, Air Conditioning Guide 1944.—W. N. GAMBRILL, industrial power dept., Consolidated Gas Electric Light and Power Co. of Baltimore.

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THE QUESTION

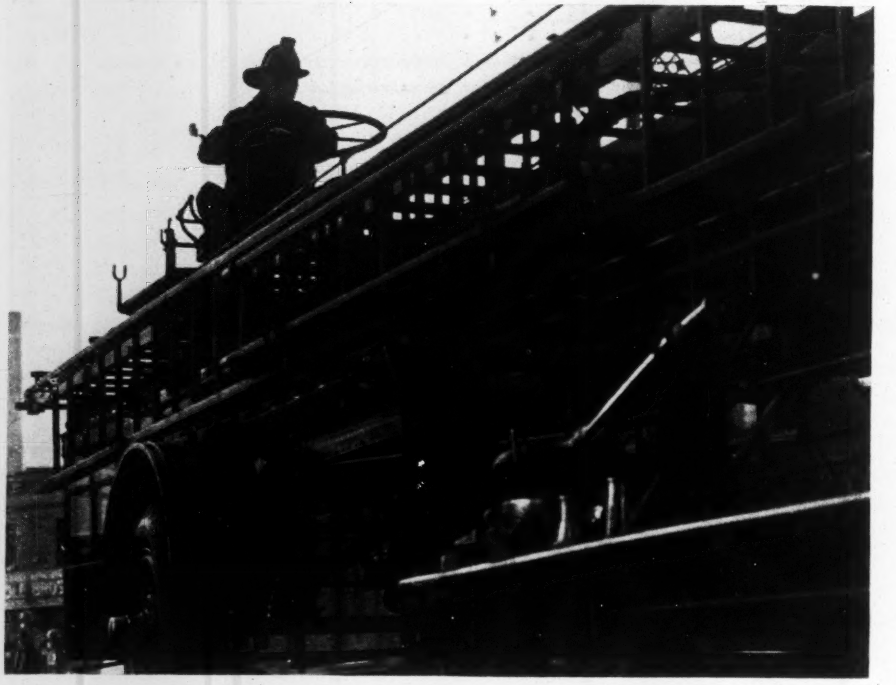
"On many moisture problems involving ventilation and the removal of moisture, it appears that the usual method of measuring the relative humidity and grains of moisture per pound in the effluent air is not entirely satisfactory. It is occasionally possible, it appears, to remove (with rather high velocities) some of the moisture in suspension rather than totally saturated in the air. If this is true, the total moisture leaving a building could not be measured by means of a sling psychrometer since that instrument would measure only the moisture that was absorbed by the air. How could the total moisture be determined?"

ON PAGE 75 of the February HPAC, I note a discussion of methods of determining the amount of entrained moisture in air.

If the amount of entrainment is not excessive, it would seem to me that one of the simplest ways of determining the moisture content would be to pass a sample of the air through a heater and then an aspirating psychrometer. In this way the wet bulb could be determined, and the amount of moisture then determined from a psychrometric chart. By exploring the condition of the sample by varying the amount the air is heated, a check could be made to assure that all entrained moisture had been evaporated. This method would have the advantage that it would not be necessary to use any kind of moisture separator, nor would it be necessary to strike a heat balance.—F. O. URBAN, supercharger engineering div., General Electric Co.

Suggestions for Reducing the

Fire Hazards of Air Conditioning Systems



All the various developments of our times have brought along with them their problems as well as their benefits. In this, air conditioning is no exception. In principle the fire hazards of air conditioning systems don't differ much from those of ventilating systems; such difference as there is, is mainly one of degree, as the conditioning systems usually incorporate a more extensive duct system; there is more mechanical equipment involved in cooling, heating, humidifying, and filtering; and higher air velocities are used.

The ducts may pierce fire walls and fire-resistive floors. A fire in the system can be very quickly communicated to all parts of the property, nullifying the purpose of the fire cutoffs unless precautions are taken to prevent such an occurrence. Experience with these fires shows that they are generally very fast and usually productive of considerable smoke. This latter is particularly serious, as air conditioning systems are, by their very nature, installed most often in buildings occupied by large numbers of people, where the panic hazard becomes a serious issue.

Fires in air conditioning systems may be divided into two general classes: when the combustion is inside the system, and when the system distributes fire or smoke, or both, which is drawn in from outside the system. Fires of the first class—that is, when the combustion is within the system—are by far the most numerous and the most dangerous.

The remedy is simple to state. Keep the system free of everything that will burn. Combustibles found within the system are usually in duct lining or insulation, combustible filters, and the accumulation of dirt and lint.

The amount of combustible rubbish that can find its way into return ducts is surprising, especially if the duct openings are near the floor level. This is particularly true in places of public assembly. In some theaters the space under the sloping floor is used as part of the ventilating system with hooded openings under the seats. This should be discouraged. Such spaces, if not cleaned frequently, may be found to contain chewing gum wrappers, popcorn bags, candy wrappers, and a miscellany of small articles of wearing apparel as well as quantities of lint. Wire mesh over the openings will keep out the larger pieces but regular and frequent cleaning is also necessary.

Any combustibles in the system, whether rubbish or insulation, will spread fire rapidly and burn vigorously due to the action of the moving air.

In considering this phase, it must be remembered that the process of combustion is somewhat different in an air stream than it would be in still air, and that in general materials will burn more freely because of the larger amount of oxygen supplied by the moving air and its fanning action. The use of combustible ducts or duct linings is definitely bad practice, as the record shows this to be a prolific cause of trouble.

It is extremely hazardous to use concealed spaces such as joist channels or roof spaces or underfloor spaces either as ducts or as plenum chambers, for the entrance of fire into these spaces immediately involves the building structure itself in fire and is difficult to attack.

Air filters present quite a problem. They are made of every conceivable material. It is unfortunate that some of the most combustible materials will make filters that are reasonably efficient and cheap. To have a filter that will not burn freely does not entirely solve the problem, however. The adhesive used, or materials used to reduce the combustibility of the filter itself, may under fire conditions be productive of smoke in large amounts or of products of combustion which may be unusually disagreeable—or even toxic—and productive of a most serious panic hazard.

Filters must be cleaned or renewed regularly and not be permitted to accumulate large quantities of combustibles. This is necessary for proper efficiency of the system as well as to reduce the fire hazard. Air filters are available that are listed by Underwriters' Laboratories, Inc., in which the fire and smoke hazards are reduced to a minimum.

To keep the system free from combustible accumulations involves matters of maintenance as well as construction. Provisions should be made for regular cleaning of the ducts and for such cleanout openings as may be necessary for proper inspection and cleaning. For obvious reasons particular care should be given to the return ducts. The proper location and screening of return air and outside air inlets will do much to keep trash out of the systems.

The causes of fire are not always known, of course, but those commonly reported involve welding or cutting torches used in repair work, workmen smoking in the system, electrical causes involving the equipment in the system, or extension cords to lamps or tools, fire drawn into the system from outside, or cigarette butts snapped into a return air intake.

The development of methods to extinguish a fire that has once started within a system or to limit its extent has been handicapped considerably by the fact that air conditioning systems vary so much that no standard arrangement applicable to all systems is possible. The systems are "tailor made" to suit the building in which they are installed, and each must be considered as a separate problem. The same principle, however, applies in all cases.

When fire or smoke is present in the system, there are three things that should be done; first, shut down the blowers; second, subdivide the system so as to prevent the travel of smoke and fire; and third, extinguish the fire.

Now shutting down the blower is simple, but subdividing the system so as to prevent the travel of smoke and fire is not.

I think you will agree that if a duct pierces a fire wall or floor that has fire doors on all its other openings, fire shutters should be installed on the duct wall openings too. This is good practice. The shutter is operated by a fusible link and should be secured to the wall so that it will remain in position even though the duct itself may collapse. It also seems quite reasonable to provide a fire shutter on the outside wall of the building, where the outdoor air duct enters to protect the system against fire or smoke from outside fires near it.

Fire and Smoke Detection

It seems advisable also to install fire shutters on all ducts where they enter or leave the filter chamber, so that a fire in any duct may be isolated from the others, and so that the filter chamber which contains most of the hazards may be isolated from all.

You will notice from all this that the best time to eliminate most of the hazards is when the system is on the drafting table. It may be both difficult and expensive to correct defects of design and construction after the system is installed.

The automatic detection and control of fire and smoke in these systems offers quite unusual problems that are not yet entirely solved but which we hope soon will be.

The accomplishment of this function by thermal means is not entirely satisfactory. A system may be discharging smoke into the building and yet there may be no heat or fire in the system itself. Or if there is fire in the system, the high velocity air currents may prevent the heat from reaching a sprinkler head or a fusible link, or may so dilute the heat that if it does reach the device it will not operate it. It seems as though it is more reliable for such automatic detection to be based on the presence of smoke in the system than by the presence of heat.

The electric eye is being used for this purpose successfully. This

Proper Design on the Drafting Board and Good Housekeeping After Installation Are Essential, Says John A. Neale

Most benefits to mankind bring their problems, too, and air conditioning is no exception. While the fire hazards of air conditioning systems don't differ much from those of ventilating systems, such difference as there is, is mainly one of degree, as air conditioning installations generally involve more extensive duct systems, there is more mechanical equipment, and higher air velocities are used. . . . The best time to eliminate most of the hazards is during the design of the system, and this must be followed up after installation by regular cleaning of the duct system to keep combustible material from accumulating, regular cleaning or replacement of air filters, etc. . . . Mr. Neale, chief engineer of Underwriters' Laboratories, Inc., prepared this material for presentation at the recent Northwest fire school at St. Paul.

device resembles in a general way the smoke alarms that are installed on smoke stacks to warn of excessive smoking. It can be so circuited that power failure, burnout of light source, or circuit trouble initiates a trouble signal and not a false alarm. As these devices will operate when smoke only is present, they should not be used to discharge water from sprinklers or CO_2 gas as there may be no fire in the system.

Where the utmost in protection is desired, such devices are installed and so arranged that the presence of smoke in the system will stop the blowers, close sectionalizing dampers, and give an alarm in the proper quarters. Once the flow of air has been stopped, such thermal devices as may be installed will be promptly operated by the heat, which, if fire exists, will bank in the ducts and operate sprinklers to extinguish fire in filter banks and fusible links to close dampers on duct outlets or at fire walls. The heat will also operate devices to discharge foam on the oil reservoirs of automatic filters or perform such other functions as may be necessary in the particular system involved.

In properties equipped with automatic sprinklers it has been realized that the currents of air which move when the air conditioning system is operating may interfere with the proper functioning of the sprinkler system by preventing the heat from a fire from rising up and opening the sprinkler head directly above. Under these conditions the heat may drift off and open a sprinkler some distance away whose water will not reach the fire.

For other reasons, too, it is undesirable for an air conditioning system to continue to operate when there is a fire in the premises that it serves. The general movement of air that it causes will fan up the fire, and fire and smoke may be drawn into the system and communicated to other parts of the premises. This situation has been remedied by connecting the sprinkler alarm system electrically with the controls on the blowers, so that the operation of the sprinkler system will shut down the air conditioning system.

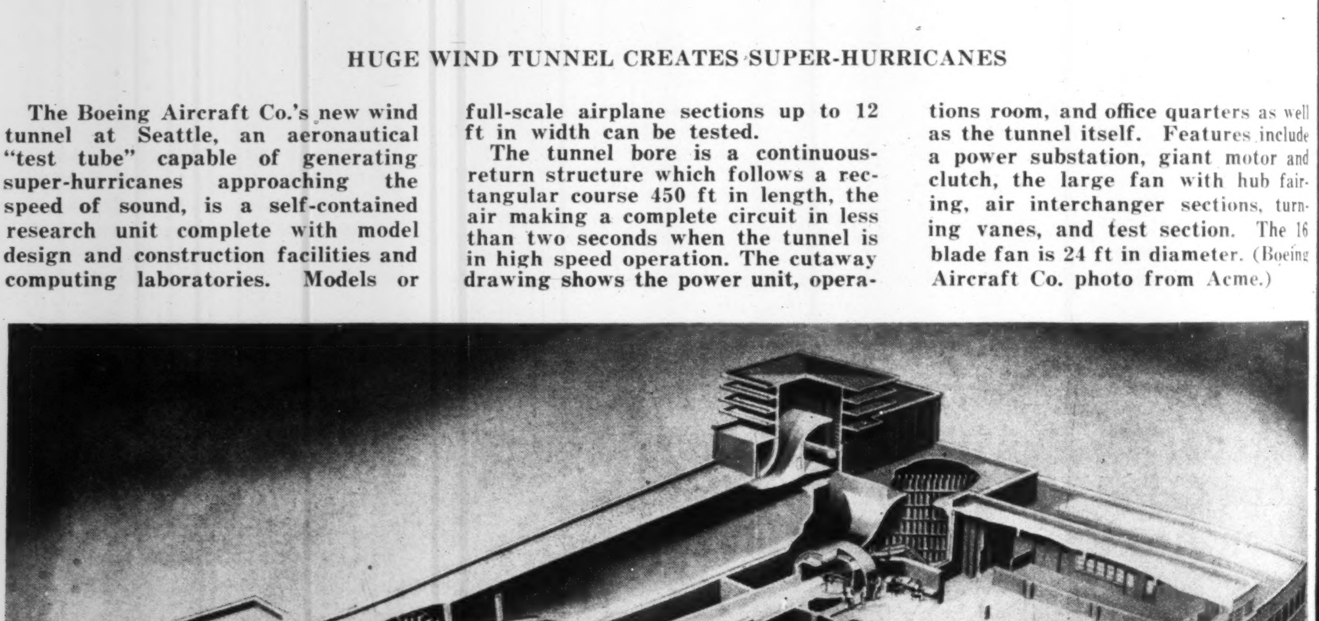
A particular hazard exists at the present time in connection with the refrigerants used in the cooling systems. Due to wartime activities some of the refrigerants commonly used are no longer obtainable. The use of any refrigerant other than that for which the system was designed should not be permitted until a careful examination has shown that it may be safely used in the particular equipment involved.

* * *

HUGE WIND TUNNEL CREATES SUPER-HURRICANES

The Boeing Aircraft Co.'s new wind tunnel at Seattle, an aeronautical "test tube" capable of generating super-hurricanes approaching the speed of sound, is a self-contained research unit complete with model design and construction facilities and computing laboratories. Models or full-scale airplane sections up to 12 ft in width can be tested.

The tunnel bore is a continuous-return structure which follows a rectangular course 450 ft in length, the air making a complete circuit in less than two seconds when the tunnel is in high speed operation. The cutaway drawing shows the power unit, operations room, and office quarters as well as the tunnel itself. Features include a power substation, giant motor and clutch, the large fan with hub fairing, air interchanger sections, turning vanes, and test section. The 16 blade fan is 24 ft in diameter. (Boeing Aircraft Co. photo from Acme.)



Steam Pressure Reducing Valves

John J. Woolfenden Discusses — from the Specifier's and User's Viewpoints — the Available Types and Their Proper Selection

A PRESSURE reducing valve is a simple bit of mechanism. Like all mechanical devices, it has its limitations and its weak points. On the other hand, it has its merits, which must be thoroughly understood in order that they be made use of. In short, it can be a valuable aid or a constant source of trouble, depending upon the degree of appreciation of its characteristics possessed by the user.

Minimum Differential

Fundamentally, it consists of an orifice of variable size, so controlled that, by varying the amount of steam passing through it in proportion to the demand, the pressure on the downstream side of the valve can be kept constant at any desired pressure less than a certain "critical value," regardless of fluctuation of pressure in the steam supply on the upstream side of the valve, provided that the supply pressure remains in excess of a certain other "critical value." Furthermore, it will perform this function, subject to these two provisions, through a range of capacity varying from the minimum to the maximum quantity of steam the valve will pass and still govern properly.

The difference between these critical pressures constitutes the least difference between the initial and the reduced pressures which will enable the valve to govern properly; in other words, it is the "minimum differential pressure" with which the valve will properly function. It is often expressed as a percentage of the reduced pressure.

This minimum differential depends largely, if not entirely, upon the inertia of the moving parts of the valve and the frictional resistance resulting from their motion and their resistance to deformation (as a diaphragm), together with the effectiveness of the means employed by the designer to overcome these resistances—i.e., the means employed to regulate, or govern, the action of the valve. In other words, it represents the "loss through the valve."

The governing, or regulating mechanism is adjustable so that, for a given supply pressure, the valve can be set to deliver steam, up to its full capacity, at any desired reduced pressure, provided that the differential pressure is not less than the critical value.

The construction of the valve is simple, although the control mechanism is subject to more or less elaboration depending upon the degree to which the designer desires to carry the refinements for the sake of increasing the sensitivity of the valve and, hence, decreasing the value of the critical differential.

The valve proper, being a throttling device, consists, in its simplest form, of a disc and seat, much like those of a globe valve. The steam, at the initial pressure, is on the underside of the valve disc and, therefore, exerts upon it a pressure which tends to lift it off the seat and open the valve. In order to reduce, to the desired degree, this unbalanced effect, the mechanism usually involves a "balancing disc," or piston, so arranged as to be subject to the initial pressure and thus render the operation of the valve smoother. The spindle of the valve, however, is in contact with the under side of a flexible diaphragm the top side of which is subjected to an adjustable, mechanical pressure, due to the action of either a spring or a weight. This pressure is adjusted so that, with a given initial pressure, the action of the mechanical pressure will tend to permit the initial pressure to open the valve just enough to produce the desired pressure reduction.

Factors Affecting Valve Action

However, since the initial pressure may fluctuate and also since the steam demand is almost certain to be more or less variable, were this the only governing arrangement, the pressure on the downstream side would also be variable. To compensate for this, steam from the low pressure side of the valve is admitted on top of the diaphragm and therefore augments the effect of the weight or spring in closing the valve. Should the reduced pressure tend to increase, the result would be a tendency to close the main valve and thus increase the throttling action, or should it tend to decrease, the main valve will be pushed up and the throttling action decreased.

Hence, with proper adjustment of the mechanical pressure, while the valve is in operation, the desired reduced pressure can be obtained, and since the valve governs from the reduced pressure side, this pressure will be automatically maintained thereafter, subject to the provisions above mentioned.

It is obvious that the action of such a valve will depend upon the size of the disc upon which the initial pressure is exerted, the size of the opening in the valve seat, the height of lift of the disc (which determines the throttling action), the size and flexibility of the diaphragm upon which the reduced pressure is exerted, the strength of the spring or the length of the lever arm and the size of the weights, as well as many other details of design which tend to increase the inertia, the friction, etc.

Types of Pressure Reducing Valves—While the above description illustrates the principles involved and, indeed, is typical of some of the simpler valves, there are several different types which may be briefly tabulated as follows:

A. Seating
- (1) Single seated.
- (2) Double seated.

B. Loading
- (1) Spring loaded.
- (2) Weight loaded.

C. Governing
- (1) Internal governing.
- (2) Remote governing.

These classifications may be elaborated upon as follows:

"A mechanical device like a steam pressure reducing valve can be a valuable aid or a constant source of trouble, depending upon the degree of appreciation of its characteristics possessed by the user." Mr. Woolfenden—of the engineering staff of Smith, Hinchman & Grylls, Inc., architects and engineers—writes on the types of steam pressure reducing valves, the fundamentals of their construction and operation, and comments on selection of the right valve size. A second article will be devoted to valve capacity.

Class A

(1) Single seated valves are, as the name implies, those provided with a single disc and seat. Such valves will close tight under zero steam demand and are suitable for "dead end" service.

(2) Double seated valves are those provided with two valve seats and two discs, the latter being arranged in tandem on a single spindle, as in a poppet valve. Such an arrangement inherently contains the elements of a balanced valve and, with the disc and seat areas suitably proportioned, would (theoretically, at least) require no balancing piston. They will not close tight, for obvious reasons, and are *not* suitable for "dead end" service, as the leakage through one or the other will allow the pressure to build up on the reduced pressure side and, in extreme cases, the wire drawing through the leaking element may very appreciably cut away the seat.

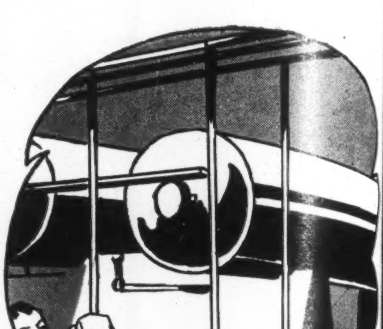
Class B

(1) Spring loaded valves are those in which the counter-pressure is applied by means of a compression spring which is provided with a suitable means for adjusting the pressure exerted, usually a nut or a screw. The springs should be protected from the heat of the steam as much as possible. This type of valve is usually designed essentially for high pressure service and is customarily used where it is desired to eliminate the moving lever and weights. One possible objection to it is that springs will "age" and, as a result, change their characteristics.

(2) Weight loaded valves are similar to that described above, in which the counter-pressure is applied through a piston or a pressure plate attached to a suitable weighted lever. Adjustment is made by changing either the position of the weights or their mass. It is customary to employ a double set of weights, one at each side of the fulcrum of the lever, and by such an arrangement very accurate adjustment can be made. Such valves are not suitable for marine service, where the motion of the ship would disturb the position of the lever. They are not subject to the effects of aging, as are the spring loaded type, but eventually wear of the bearings will more or less affect them.

Class C

(1) Internal governing valves are those in which the pressure for controlling the valve is taken from the reduced pressure side within the body of the valve itself. They generally operate best under relatively stable conditions, as the behavior of the steam within the valve will vary with the steam demand. They are usually considered suitable where the load does not fluctuate or where some variation in the reduced pressure is not objectionable. They are usually lower in price than the remote governing type but are not so well suited as



the latter to certain classes of work.

(2) Remote governing valves are those which are provided with an auxiliary mechanism so designed that the low pressure steam for governing can be taken from the main at a distance from the valve. Under certain conditions, this may be a very decided advantage, as will be shown later. Some valves may be so designed as to be capable of being used as either internal governing or remote governing valves, as desired. In such valves the auxiliary mechanism is contained within, or attached to, the valve body. Other valves are adapted to remote governing by the installation of the requisite separate pilot mechanism and the steam for control must, therefore, be taken from the main outside the valve. Within reason, the distance from the valve at which the main is tapped for this steam makes no more difference than it would in the case of a pressure gage, provided that the pipe conveying it is so arranged (as is required for the gage) that the pressure transmitted is static, i.e., the pipe should be of adequate size and should be "trapped" throughout its length so as to be full of water from end to end, the changes in pressure being, in consequence, transmitted by a slight displacement of the liquid.

Diaphragms—The matter of diaphragms deserves some attention. There are two common types, viz., non-metallic and flexible metal. The former are usually found in valves designed for operation on low pressure work, while the metal diaphragms are ordinarily found on valves for use on high pressure. It is obvious that the two types require different types of control mechanisms as the non-metallic is

PRACTICAL OPERATING KINK ADDS TO COMFORT IN STORE

A very practical application of night air cooling is employed in a number of Jewel food stores during the summer to assure a "fresh" and comfortable indoor condition for the following morning.

A stoker timer is used in the electrical circuits of the motors driving the exhaust ventilating fans, set to run the fans for seven minutes out of each hour during the night. When the store is locked up in the evening, the transoms over the doors are left cracked open slightly to allow air entry. Thus, during the night, the store is swept out by outdoor air periodically each hour. In the morning, when the store opens, it's a lot more comfortable than if it had been closed up tightly all night.

uch more readily deformed than he metallic and therefore permits reater primary displacement. Conequently, the valve spindle may be rovided with a suitable pressure late bearing against the diahragm and be actuated directly by s motion.

The weight loaded, non-metallic iaphragm type of valve is often sed in central heating work, where he initial pressure at the valve is sually from 8 to 10 psi, and rarely ver 30 psi.

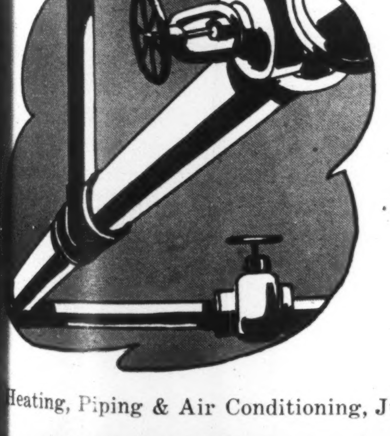
The non-metallic diaphragm, owever, under the influence of the eat from the surrounding suraces, sooner or later loses its elasicity and must be replaced.

The metal diaphragm, on the ther hand, is less flexible than the on-metallic and, size for size, on ccount of the minimum thickness equired for mechanical strength, s capable of much less motion (deormation) than the non-metallic. or that reason it is not used to mpart direct motion to the valve pindle but usually actuates an uxiliary, or pilot, valve which in urn controls the admission of eam to a piston which actuates he valve proper, or the main valve, f that term is preferred.

The metal diaphragm will age, n time, and lose its flexibility and ay ultimately crack, but it will ormally have several times the life f the average non-metallic diahragm.

The size of the diaphragm will, f course, depend upon the pressure which the valve is to reduce the eam; the lower the pressure, the rger the diaphragm required.

Generally speaking, valves for se on low pressure systems seldom ave metal diaphragms, but the onverse is not always true, for if the arrangement is such that the diaphragm is protected against direct contact with the steam and from too much heat, a non-metallic diaphragm can be used for moderately high pressure service.



Valve Size Selection—In some makes of valves the inlet and outlet connections are the same size; in others, the outlet is larger by an arbitrary increment. A moment's thought will show that the principal advantage of this latter arrangement is that it provides for a larger connection on the outlet than on the inlet, which is proper, but if the valve is chosen on the basis of the outlet size, not only may the inlet opening be of an incorrect size, but the valve capacity may not be suitable, unless the working parts are proportioned to the load.

To exactly provide for the proper expansion of the steam in the valve itself would be difficult, since the load usually varies and what might be suitable for a light load might not be equally adapted to a heavy load, and vice versa. Given a reasonable length of pipe before the first take-off on the low pressure side of the valve and the expansion will take care of itself.

Furthermore, one of the most certain ways to get into trouble with a pressure reducing valve is to select it on the basis of pipe sizes only.

It is very unfortunate that reducing valves were ever listed on the basis of pipe sizes and equally unfortunate (in my opinion) that they were ever made to stock size, as regards the sizes of inlet and outlet piping.

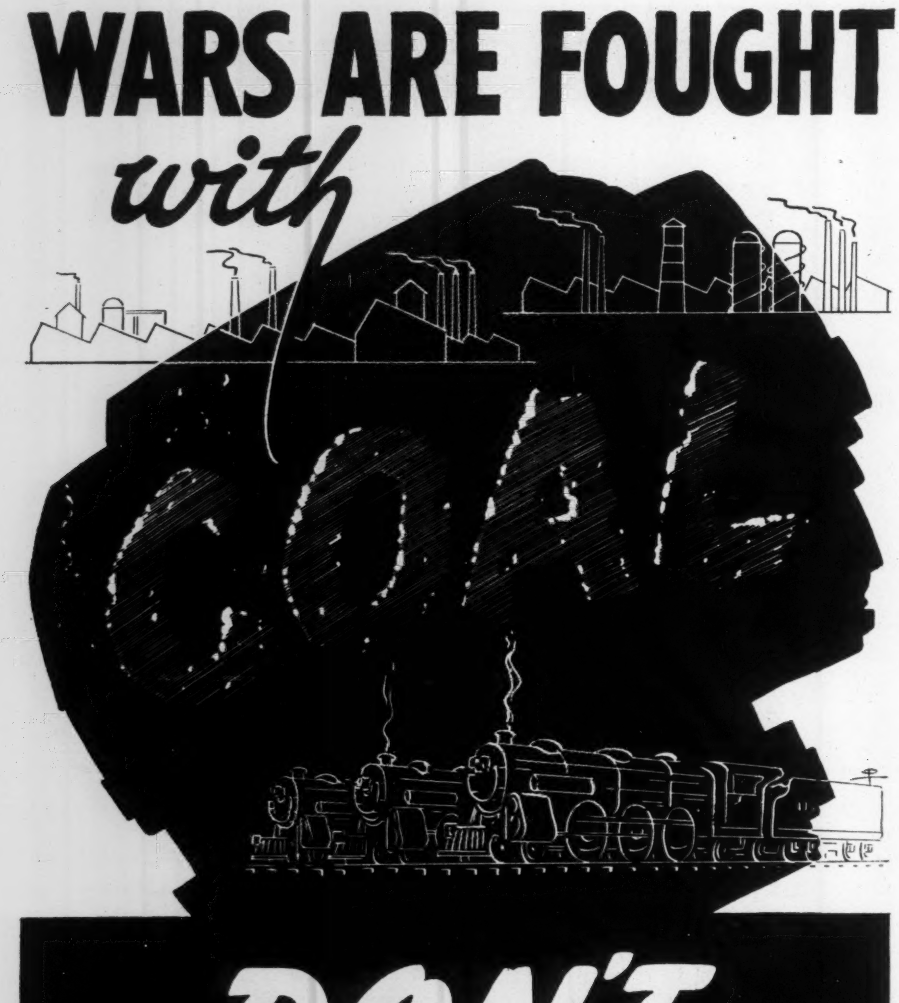
In fact, one manufacturer in the past made a practice, in the case of flanged valves, of providing the valve body with flanges to fit the flanges on the connecting pipes. This valve was of the straightaway pattern and the size required, on the basis of the manufacturer's rating, was usually smaller than the size of the supply connection.

Since, when one buys a reducing valve it is not a case of purchasing so much metal but purely a matter of performance of a certain function, it is logical that the selection should be made on the basis of that performance and on no other basis. It is just as logical to offer to pay an artist for the canvas, paint, and time which were required to produce a painting as to select a reducing valve by pipe size.

Unless the pressure reduction is very slight, it is a safe guess that valves picked upon the basis of pipe size will be too large. Unlike many other items, too large a capacity in a reducing valve is not a matter of "playing safe"; quite the contrary, it is more than likely to be (so to speak) a fatal mistake.

For a valve that is oversize for normal or maximum load will be much more so for lighter loads and under the decreased steam demand will more or less wire draw, with the result that, at the least, the seat will be rapidly cut away.

The writer has seen—and only four or five years ago—a 3 in. reducing valve which was so badly eroded by wire drawing that *when the valve was closed* (?) it was possible to insert an ordinary lead pencil through any one of several holes resulting from the erosion of the seat. This cutting action clearly showed that the valve was over-



CONSERVATION POSTER USED BY ARMY
(See article by C. E. Miller in this issue)

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size and a check on the load substantiated this fact. The damaged valve was replaced by two 2 in. valves in parallel. Either one of these will carry the average load nicely, and the two together will take care of the probable maximum which can be expected to occur at rare intervals, if at all. As far as the writer knows, the two have not been used simultaneously since their installation some years ago.

Once in a while one may find a reducing valve of too small a capacity. The writer, in over 40 years, has seen but one such case, and in connection with that one it may be of interest to note that one of the engineers from the public service company which supplied the steam for that installation remarked, "We often find reducing valves too large, but these are the first I have seen which are too small."

That does not mean that the capacities can be selected by guess, at random, without fear of getting valves too small, for that is by no means the case. It does mean, however, that the tendency is to err on the "safe" (?) side.

In this particular case it seemed as though the valves must have been ordered by pipe size (although the capacities were specified) and that the manufacturer, who undoubtedly had seen most reducing valves ordered too large, wisely had put smaller "insides" in the bodies to avoid the evil effects of oversize valves.

Fortunately, the valves were in a system so arranged that it was possible to use the "steam meters" to measure the condensate from each valve. By varying the load it was possible to ascertain the maximum quantity of steam passed with the specified pressure drop. It was found that the valve capacities were about one-half of the specified quantities. The trouble was corrected in this case by having the manufacturer change the "insides."

To put the matter briefly, a reducing valve should be so selected that under normal conditions it will be as nearly as possible wide open. It is true that loads vary—even heating loads are far from constant, and where the maximum and the minimum loads are fairly well separated, it is most desirable to split the capacity of the reducing station into units. Depending upon the variation, for two valves the proportion might be 50:50 or 60:40; for three valves 30:30:40 or 20:30:50 might be proper. The 30:30:40 combination will handle the load in combinations of 30, 40, 60, 70, and 100 per cent; the 20:30:50 arrangement will give load capacities of 20, 30, 50, 70, 80, and 100 per cent. On an installation requiring considerable steam capacity (such as the steam supply to a large building) there might easily be four or more valves, depending upon the requirements. In any case the capacities of the valves should be based upon the probable load requirements with emphasis on the minimum, the average or normal, and the maximum conditions.

Heating, Piping & Air Conditioning

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

Journal Section

Air Disinfection in Ventilation

By W. F. Wells,* Philadelphia, Pa.

SUMMARY—The author reviews the theories developed and the progress made in the study of respiratory contagion and in the control of air-borne infection. Conclusions are drawn regarding use of ultraviolet rays, aerosols and disinfectants in sanitary ventilation. Suggestions for further progress are made

EVER SINCE cave men vented smoke from their fires, ventilation has been associated with heating. Though temperature control still largely dictates air confinement, the problem today is rather to vent air vitiated by occupants of enclosed spaces than products of combustion. Before the dogma of *contagia* was displaced by the germ theory of disease, chemists measured ventilation load by determining the equilibrium concentration of carbon dioxide expired by occupants, which defined dilution with fresh air.

When bacteriologists caught infected droplets expelled in talking, coughing and sneezing only on culture plates within the immediate vicinity of a subject, they concluded that the flight range of infection could not exceed an arm's length and was therefore of little concern in ventilation. Most organisms in dust of inhabited spaces were found to be harmless varieties from decomposing matter rather than pathogenic organisms from diseased tissues. Chapin voiced the opinion, held by sanitarians, that contagion was spread indoors by *contact* between persons sharing enclosed atmospheres:

> Bacteriology teaches that former ideas in regard to the manner in which diseases may be air-borne are entirely erroneous; that most diseases are not likely to be dust-borne, and they are spray-borne only for two or three feet, a phenomenon which after all resembles contact infection more than it does aerial infection as ordinarily understood. Tuberculosis is more likely to be air-borne than is any other common disease. (1)†

Relieved of responsibility for venting air-borne agents of infection, engineers turned attention to physiologic effects of ventilation upon health. The regulation of temperature, humidity and air motion provided ample physiologic grounds for controlling the indoor climate within which civilized man spends ever more time, and ventilating engineers contributed air conditioning to the development of scientific control of our environment during the present century. Though hygiene resisted efforts to lower standards of ventilation, economy again pressed for further confinement of the air we breath.

The environmental control of epidemic respiratory contagion by sanitary measures during this period did not match the reduction of intestinal infection conveyed by water, food and milk, or of insect-borne infection; nor did the strict application of aseptic techniques entirely eliminate hospital cross-infection. Epidemiology, focussed on residual respiratory infections, gradually dispelled the notion that the dynamic spread of contagion among aggregations breathing common atmospheres could be wholly explained by a literal interpretation of *contact* infection. (2).

The classic work of Laidlaw and his associates, upon air-borne spread over considerable distance, of the viruses of dog distemper and influenza (3), Lurie's experiments on tuberculosis, dust-borne between animals in separate cages (4), observations on air-borne surgical infection by Hunt and Meleney (5), Cruickshank's studies of air-borne infection of burns (6), the Colebrooks' analysis of the role of nasopharyngeal organisms in puerperal infection (7), and the work of Allison on streptococcal infection in fever wards (8), and of McKhann on nosocomial infection in children's wards (9), are examples of the variety of evidence accumulated in recent years.

Improved bacteriologic procedures in sanitary air analysis also have reinterpreted Flugge's theory of droplet infection (10), proved quantitative inhalation of droplet nuclei infection to the lung (11), demonstrated habitual exchange during winter months of respiratory flora among aggregations occupying enclosed atmospheres (12), and measured the sanitary inadequacy of present ventilation practice and the potentiality of air disinfection in control of dynamic spread of air-borne infection (13).

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†Numerals in parentheses refer to Bibliography.

For presentation at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Grand Rapids, Mich., June 1944.

Elements of three types of *Bacteriologic Procedures in Sanitary Air Analysis* presented to the Committee on Ventilation and Atmospheric Pollution of the Industrial Hygiene Section of the *American Public Health Association* by the Subcommittee on Bacteriologic Procedure (14) have been summarized with special reference to air disinfection in the *Journal of Bacteriology* (15).

1. ***Sanitary survey of inhabited atmospheres:*** **Rapid methods of collecting particles from large volumes of air enable the routine sampling necessary to obtain statistically insignificant indices of sanitary ventilation.**
2. ***Experimental studies of bacteria suspended in controlled atmospheres:*** **The mechanics of air-borne infection and control by ventilation have been studied bacteriologically in experimentally controlled atmospheres.**
3. ***Measurement of sanitary ventilation:*** **By quantitative sampling of test organisms added to atmospheres under different ventilating conditions, the hygienic importance of air disinfection has been demonstrated.**

These procedures in 1935 disclosed higher bactericidal power of ultraviolet light against microorganisms suspended in dry air than in drinking water (16) and in the following year these observations were practically applied in surgical air asepsis (17). The effect of radiant disinfection of air in reducing surgical infection (18) and cross-infection in pediatric wards (19), a nursery (20), and an orphanage (21), and in the environmental control of epidemic spread of contagion in schools (22), now provides experimental evidence of the importance of air-borne infection.

While prevention of cross-infection in hospitals is only one field of ventilation, purveyors of breathing air in public places should also be concerned in the epidemic spread of air-borne infection. To make a public air supply proof against dynamic spread of contagion requires only that the number of new cases does not exceed the number of exposures, for then an epidemic can not grow. The epidemic spread of *volatile* childhood contagions in day schools has thus been checked when air disinfection eliminated test organisms ten times more rapidly than normal winter ventilation (23), and there is no reason to believe that epidemic spread of other air-borne infections cannot be controlled equally well by sanitary ventilation (24).

A committee on the study of the use of ultraviolet rays as a sterilization agent in hospitals of the Council on Hospital Planning and Plant Operation of the *American Hospital Association* reported favorably in 1940 (Bulletin No. 203). In 1942 the Council on Physical Therapy of the *American Medical Association*, after thorough investigation of radiant disinfection of air, issued a *Report on Acceptance of Ultraviolet Lamps for Disinfecting Purposes* (25). A conference of representatives of the Council, U. S. Public Health Service, *American Hospital Association*, the University of Pennsylvania, and the General Electric, Westinghouse and Hanovia Chemical and Manufacturing Companies met in Philadelphia at the time of the Annual Meeting of the ASHVE to consider the problem of dosage in the radiant disinfection of air. Suggestions made at this conference were utilized by the Council in preparing its revised report. (*Journal American Medical Association*, 122:503-4, 1943.)

It was the belief of those present that progress had been made toward the codification of sanitary ventilation, insofar as approval of ultraviolet lamps was concerned, and that it would be necessary to meet again at some later time to consider the problem of intensity of irradiation within habited spaces. The necessity for this was recognized by the Council on Physical Therapy in its reports, *The Council cannot undertake supervision or assume responsibility for the satisfactory performance of any particular installation.*

A second conference on sanitary ventilation, called at the time of the 1944 Annual Meeting of the ASHVE in New York City on January 31, also included, in addition to members of the first conference, representatives of the Army, Navy, Departments of Health and Labor of the State of New York and the New York City Health Department and Northwestern University.

The main problems which faced the second conference may be illustrated by an analogy. To intercept aircraft, it is necessary to lay down a properly directed and sufficient amount of flak, using weapons of suitable design. The responsibility for the design and production of the weapons belongs to the Ordnance Department; that for their proper use, to the Artillery. Likewise, in the interception of air-borne bacteria, the Council on Physical Therapy has assumed the responsibility for passing on the weapon, the source of radiation. But here the responsibility for the efficiency with which the weapons are used, the direction and intensity of the ultraviolet rays, had not yet been assumed by any authoritative body although the need has become manifest.

A formula was proposed (26) for evaluating radiant disinfection of air. The distribution of irradiation within enclosed spaces depends upon the length of the rays, as determined by their position and direction. Average intensity of irradiation, which corresponds to the concentration of disinfectant in chemical disinfection, may be determined by summing the products of radiation (milliwatts) times length of rays (feet) between the source and the point at which the rays disappear from the atmosphere, divided by the volume of the enclosed space (cubic feet). This value, divided by the maximum uniform intensity obtainable from the radiation in a cubic space of the same volume, might be called the efficiency of irradiation.

Maximum disinfection of an enclosed space would be achieved if average intensity of irradiation were uniformly distributed throughout the entire space. In practice, however, it may not be feasible to expose occupants to the intensity required to disinfect. The amount of disinfection throughout the room, for a given average intensity of irradiation, is dependent upon circulation of the bacteria from the occupied to unoccupied zones. The average disinfection actually achieved can be determined by bacteriological tests, and the fraction that this represents of the maximum, which is theoretically obtainable, can be computed. This fraction might be called the efficiency of disinfection.

The principal purpose of bacteriological tests is to determine the average rate of removal of significant air-borne organisms from the room by sanitary ventilation. Under special circumstances, as in use of light curtains, protection may exceed the average disinfection as defined by these tests. In general, however, the concentration of light in regions away from the occupants will result in less removal of organisms en route from person to person than by average disinfection in the room. The efficiency of irradiation and disinfection described above may indicate the extent to which protection to the occupants differs from that indicated by the average disinfection determined by bacteriological tests. It has been found in simplest cases, such as schoolrooms, that with low efficiency of irradiation and disinfection, higher average disinfection would be required to accomplish approximately equal protection against classroom spread of certain childhood contagions. It was therefore proposed that the hygienic rating of disinfection be raised as the indices of irradiation and disinfection efficiencies are increased by good design.

These procedures for determining dosage apply particularly to irradiation of organisms in minute particles which drift around in the air like cigarette smoke until they are breathed into the lung, vented from the room with fresh air, or destroyed by disinfection.

Some believed that these are the primary cause of the epidemic spread of air-borne contagion, and that ultraviolet light is peculiarly effective against this type of spread (27). Others maintained that dust is of primary importance as a vehicle and that since coarser dust particles do not drift around in the same manner as droplet nuclei but tend to be raised, settled, and raised again without being maintained in the atmosphere, they were less likely to pass through the irradiated zones in the upper parts of the room. It was further suggested that even if exposed in the irradatied zones, they could not be so readily disinfected.

Bacteriological evidence was adduced that certain organisms survive in dust, where they have been found in considerable numbers both in the air and on the surfaces (28). There is epidemiological evidence of the spread through air of streptococcal infections of the nose and throat by dust, and in hospitals, where lint from the bedding of infected persons may accumulate, this could be a serious matter (29).

In a serious study of haemolytic streptococci in the dust of hospital wards, and their relationship to infection, on the other hand, no conclusive example of a hospital cross-infection conveyed by dust was noted (30). Also, the typical pattern of epidemic spread of contagion among aggregations of well persons could not satisfy conditions arising from the hypothesis of dust-borne infection; the generations observable in epidemics of measles, mumps, etc., would, contrary to epidemiological patterns observed (31), become indistinct if the infection was diffused in accordance with the activities which raise dust. On the spread of epidemic meningitis through troop transports, Greenburg states, "so far as we could see the upper and lower bunks did not show any real difference which would cause us to believe that the field of infection was more concentrated in the lower areas of the room" (32). Moreover, the rapidity with which influenza spread in 1918 and the sharpness of the decline (33) is not compatible with the dust hypothesis. Nor has the correlation between extremely dusty atmospheres and epidemic spread of disease impressed the epidemiologist (1).

The difficulties of applying this formula in determining dosage required for disinfecting dust may render it impractical for such use.

It was suggested for controlling spread of infection by dust that all the lights be installed everywhere that the traffic would bear. Economy would not be a consideration. Others pointed out that, unlike droplet nuclei, dust might be controlled better by other measures than disinfection. It was easily removed from recirculated air by filtration or by electrostatic precipitation, or from surfaces by proper janitorial care, or laid by sanitary measures which make for air cleanliness (34).

Some considered that both problems should be given serious thought; that certain diseases might be spread more readily by droplet nuclei (*i.e.*, measles) and others by dust (as dried sputum in the spread of tuberculosis). In fact, air disinfection might provide a useful means of experimentally distinguishing modes of spread of respiratory infection and replacing opinion with significant data.

Furthermore, it was pointed out that the conditions for installing lights would also complicate the formulations. In crowded barracks with two and three levels of beds, the conditions would not be the same as in a schoolroom; nor would they be similar in a ward where the patients are confined to their beds.

Problems other than insuring adequate disinfection in an experimental demonstration were considered. For instance, in some diseases infection may spread or be prevented without clinical manifestations of the effect or irradiation, and bacteriological techniques must sometimes be applied to reveal the pattern of spread of infection. Chronic diseases like tuberculosis are difficult to subject to experimental study among human beings.

The question of susceptibility of the individuals in the aggregation under study may be vital if, as in measles, immunity is conferred by the disease. Therefore, the study of school children will differ from that of adults, although patterns of spread in influenzal infections may be similar in adults and children. Multiple infections, as in colds, may hide protection in the particular aggregation being observed (22).

Above all, if the study is intended to produce significant evidence for or against protection, the design of the experiment must provide a proper setting. Some means of identifying infections contracted within an atmosphere, or coverage of atmospheres shared by an aggregation sufficient to prevent multiple infections, is necessary to demonstrate protection by air disinfection. For instance, the incubation period may define secondary incidence of measles, but to determine whether influenza can be prevented in a barrack, it may be necessary to eliminate the possibility of widespread exposure in mess halls, recreation rooms, etc., of the individuals selected for study.

The new theory of air-borne infection revived interest in fumigation, which Chapin (35) so effectively dismissed. Although intermittent disinfection remains as a vestige of terminal fumigation, the interception of organisms en route from person to person by concurrent disinfection really is a ventilation concept. Leonard Hill (36) first proved the possibility of disinfecting air with tolerable concentration of atomized hypochlorites in 1928 and 10 years later Mastermen developed this method to meet a growing demand for air disinfection (37).

Trillat, the French bacteriologist, at about the same time advanced a theory of aerosol disinfection based upon the hypothesis that particles of disinfectant would unite with particles of infectant to form a higher concentration of the former than would be possible with the same amount in gaseous form (38). British workers, developing this theory by atomizing hexyl-resorcinol dissolved in various glycols, obtained effective results even with negligible traces of hexyl-resorcinol suspended in propylene glycol (39). A group of Chicago workers under Robertson, attempting with detergents to improve this aerosol, found that propylene glycol without the hexyl-resorcinol accomplished similar results (40) and in vapor form gave results equal or superior to glycol aerosols (41).

Glycols, unlike former fumigants, are not true bacterial poisons and do not obey the normal law of disinfection. Their action seems to depend *inter alia* upon some hydroscopic quality intimately associated with humidity (42). This may help to explain why their action is closely limited to saturation ranges and why glycols with higher boiling points, such as triethylene glycol (43), and dipropylene glycol (44), which reach saturation in smaller concentration, disinfect in much lesser concentration than propylene glycol.

A clinical test of each of these three chemical methods of disinfection, empirically applied, has been favorably reported (45). Ventilation problems are, however, involved in the regulation of small concentrations of disinfecting gases, or vapors near saturation (46). The evaluation of practical performance on a wide enough scale and over sufficient time would seem to be a desirable subject for a future conference on sanitary ventilation; to consider the factors in the control of air-borne infection by chemical disinfection.

Conclusion

Scientific investigations and practical experience during the past decade, therefore, indicate that air disinfection can reconcile growing pressure to cut down the actual volume of fresh air displacement in air conditioning with growing demand for increased sanitary ventilation in the prevention and control of air-borne infection.

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REPORT ON A MEMBER OVERSEAS

Members of the St. Louis Chapter were greatly interested in the report by George Myers on the activities of Lt. John H. Carter, USNR, who has been in the Navy for the past year and a half.

"Jack" was commissioned in the Navy in December 1942 and attended Indoctrination School at Tucson, Ariz. He embarked on a slow convoy to Africa and his duties there included a variety of assignments such as: security officer, gunnery officer, billeting officer and division censor. During the Sicilian invasion he was assigned to special duty, which included registration, identification and redistribution of naval personnel, who were lost from their commands or had suffered from shellshock.

Last September he attended the ceremonies connected with the visit of General Charles DeGaulle and then for several months served on General Court Martial. Following his transfer to amphibious duty he was recently appointed Flag Secretary to the Admiral and will soon be assigned to a new flagship.

The Engineering Control of Some Solvent Hazards in War Industries[†]

By S. C. Rothman,[‡] New York, N. Y.

SUMMARY—The author reviews the toxic effect of various chemicals and solvents, particularly those used in war industries, and discusses the reaction of the individual upon exposure. Methods of controlling or preventing exposure of the operator are evaluated and suggestions are made for selecting the best type of control.

Introduction

THE ENGINEERING control of solvent hazards in War Industries, however magnified or spectacular they appear, due to increased production demands, follow in principle the same sound, practical, common sense, proven applications which were developed as an outgrowth of peace time initiative, foresight and progressiveness. New problems and intensification of old ones serve only to challenge the imagination of those directly concerned with this vital problem.

The broad over-all aspects of control and prevention of ill health resulting from the careless, ignorant misuse of industrial solvents can best be effected by mutually integrating the cooperative efforts of management, the worker, the community at large, industrial physicians, nurses, safety men and industrial hygiene engineers. In the present discussion an attempt is made to outline the role of the industrial hygiene engineer in the great drama unfolding itself when our very existence as a free nation depends so much upon the output of our war industries.

To emphasize the importance of engineering control, some of the apparent toxic effects of chemicals, especially solvents, will be reviewed.

According to Foulger,[1,2,3*] The initial reactions of living, intact, human and animal organisms to foreign chemicals, which when introduced into the body may have a systemic effect (as opposed to a purely local action), are the same regardless of the structure or physical properties of the chemical. They are the same no matter what the route of absorption of the material. It seems quite possible that serious organic injury from harmful chemicals occurs more often as a result of an acute exposure of relatively short duration, superimposed upon the accumulated effects of a prolonged low grade exposure, than it does from individual, well isolated, acute incidents without the background of chronicity.

To quote Foulger directly, "First effects of exposure to toxic chemicals consist of a few simple symptoms and certain definite signs, which are the same in exposures of many kinds. The symptoms are: easiness of fatigue, headache, gastro-enteric disturbance (nausea, loss of appetite, a feeling of fullness of the stomach, gas on the stomach, pain in epigastrium), dizziness, precordial pain, pain or tingling in the extremities, and dyspnea on slight exertion. Of course, not all are present in all cases. They are, at first, indications of functional disturbance only and not of organic injury. Of these symptoms, easiness of fatigue is probably the most universal and usually the first to appear."

Von Oettingen[4] states: "In the paraffin series the first fractions (pentane and hexane) are relatively non-toxic, having low narcotic and irritating properties. The next higher boiling fractions have more marked narcotic and irritant properties and a narrow margin of safety (difference between the minimum narcotic and minimum lethal concentrations). The lowest boiling fraction of the olefines also has narcotic properties but a comparatively wide margin of safety, while the higher homologues are more potent as narcotics and are more irritating. The lower boiling fraction of cycloparaffines has narcotic properties but is less irritating than the corresponding olefines. The higher boiling cycloparaffines and the unsaturated paraffines are potent narcotics and have a narrow margin of safety.

"The lowest boiling fraction of aromatic hydrocarbons (benzene) has narcotic properties and produces injurious effects on the blood and blood forming organs. The next two higher boiling fractions (largely toluene, ethyl benzene and xylene) have slightly greater narcotic and irritant properties and a smaller margin of safety. They have, however, less marked hematotoxic action. The highest boiling fraction has marked narcotic properties but is least dangerous because of the low volatility."

"The main difficulty encountered in determining the health hazards of hydrocarbon solvents arises from the fact that different brands of solvents have varying percentage composition of paraffines, olefines, cycloparaffines and aromatic hydrocarbons."

Flury[5] classifies the toxicity of common solvents as follows:

1. Those which are harmless under ordinary conditions of industrial use, but dangerous if their vapors are breathed in high concentrations.

2. Those which cause secondary reaction in the body, from which a quick recovery is possible if the damage is not severe.

3. Solvents which may cause secondary effect which, when not fatal, may be irreparable. This group must be handled with the greatest of care under proper controls.

Time does not permit running the entire gamut of solvent hazards. Consideration, therefore, is devoted to a few of the most common types which are finding widespread use in war industries. Physical, chemical or toxic properties are summarized in Table 1. The generally recognized hazards in the use of organic solvents are fire and explosion, bodily contact, and toxicity. In this paper, consideration will be

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[†] Similar information was given in address at the Greater New York Safety Conference 30, March 1944.

[‡] Captain, Sn. C., 2nd S. C. Industrial Hygiene Engineer.

[*] Superior numerals refer to Bibliography.

For presentation at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers.

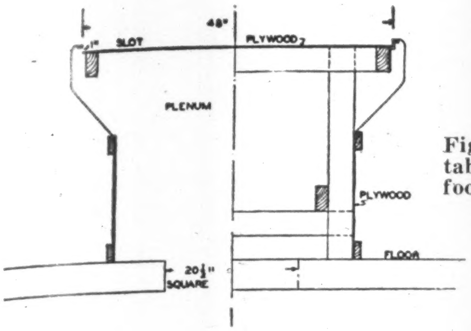


Fig. 1—Section on lateral ventilated table. Air flow = 50 cfm per square foot table surface

given only to the possible control of toxic manifestations.

Engineering Control

The engineering control of atmospheric contamination due to the misuse of toxic volatile solvents is primarily one of the most important functions of the industrial hygiene engineer and may best be achieved by one or more of the following general methods: (1) substitution of less toxic materials, (2) isolation of those processes which produce contamination, (3) dilution with uncontaminated air, (4) control at point of generation or dissemination, (5) respiratory protective devices, and (6) maintenance, housekeeping, and education of the worker. To illustrate the specific application of these principles, a few important solvents have been selected and an attempt will be made to show by their typical usage how best their attendant hazards may be minimized in war industries.

Benzene (Benzol—C_6H_6): Benzene, an extremely volatile and inflammable solvent, is used as a basic material for the manufacture of aniline, picric acid and phenol. Under various trade names it is used as a substitute for toluol in paint removers. As a solvent in the coating and cementing of fabrics with natural rubber and other operations, benzene is utilized extensively. It is probably the best natural solvent or softening agent with or without the addition of some chlorinated hydrocarbons or a ketone, for example, butanone. The cementing hazard referred to previously has been most effectively controlled by employing cements containing toluol or trade name processed petroleums which contain a large proportion of toluol and by conducting the cementing on lateral or downdraft ventilated tables. Design sketches (Figs. 1 and 2) of these tables will be found in a paper published on this subject by Thomas and Tebbens.[6]

A solvent naphtha such as hydrogenated naphtha has been used successfully in place of benzol as a flotation agent for the polishing material in the polishing of reflectors.

Inasmuch as the nitration of benzene is an enclosed process, the small amount of benzene liberated into the general room atmosphere has been kept at safe levels by means of: (1) roof ventilators with mechanically driven fans, and (2) by keeping the doors and windows open as much as possible. Workers making repairs on benzene nitrators are required to wear gas masks (chemical-filter respirators) or U. S. Bureau of Mines approved (Type B Hose Masks) supplied-air respirators. Choice depends on the type of repair and duration of exposure.

Wilson,[7] as a result of his studies of 1,104 workers engaged in the manufacture of synthetic rubber, suggests keeping benzol concentrations well below 100 ppm.

In the one notified British case[8] of chronic benzene poisoning which ended fatally in 1942, anemia was attributed to exposure to rubber solvent said to contain not more than 5 per cent of benzene. Estimation of the benzene or of a mixture of benzene and toluene in the air in the vicinity revealed 1 part in 10,000 (100 ppm). One non-fatal British case reported arose as a result of the use of airplane dope containing less than 15 per cent benzene in the mixture.

According to Henry,[9] chronic benzene poisoning in England is less common, probably because of increased precaution.

Toluene ($C_6H_5CH_3$—phenyl methane, toluol, methyl benzene): Toluene is used in the manufacture of explosives, drugs, perfumes and dyes. Widespread use is made of it as a solvent for gums, resins, oils and many types of cellulose esters. It is used in the lacquer coating for impregnating fabrics, paper and articles made of various other materials. In the aircraft industry it is used as a thinner in a special paint necessary for coating fusilages, wings, etc., where application is by dipping and spraying. Due to the acute shortage of toluene, caused by its being diverted to explosive manufacture, several possible substitutes have been used by lacquer manufacturers and users. A petroleum product called hydrogenated naphtha, the aromatic content of which is much higher in the series than the straight run petroleum naphthas, offers an interesting possibility. For most uses, such new mixtures are better solvents than the straight run naphthas. They have a surprisingly high degree of tolerance or compatibility of nitrocellulose in lacquers and can be substituted for toluene almost gallon for gallon in such formulation. The use of hydrogenated naphthas decreases the health hazard as well as the fire hazard.

Based upon a study of 106 painters in a large airplane factory exposed to the inhalation of toluene

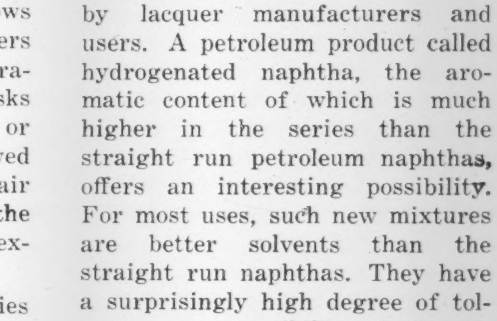


Fig. 2—Downdraft ventilated table

Table 1—Properties of Some Important Solvents Used in War Industries

Solvent	Commercial Synonym	Limits of Infl. by Vol. Per Cent		Explosive Range	Specific Gravity		B. P.	Toxic Limit[a] Parts per Million	Hazards			Effect on Man
		Lower	Upper		Sp. Gr.	Comp. with Air			Fire	Explosion	Dermatitis	
Acetone	Dimethyl Ketone	2.5	12.8	10.3	0.790	2.0	56 C	200 (1)	+	+	+	Irritant, Dizziness
Amyl Acetate	Banana Oil	1.1		(F.P.-94 F)	0.868	4.5	147.6	400 (2)	+		+	Irritation, Dizziness, Nausea
Aniline	Aniline Oil			(F.P.-131 F)	1.022	3.22	184.4	5 (3)				Cyanose, Excitation, Coma
Benzene	Benzol	1.4	6.8	5.4	0.879	2.7	80	100 (4)	+	+	+	Acute Narcotic, Chronic Bleedings Fatigue, Blood Changes
Benzine	Petroleum Vapors	1.1		(F.P.-0 F)	0.625	4.48	35-80	1000 (12)	+	+	+	Intoxication, Narcotic
Butanol	Butyl Alcohol	1.7		(F.P.-115 F)	0.811	2.55	117.7	100 (5)	+		+	Excitation
Butyl Acetate	n. Butyl Acetate	1.7		(F.P.-100 F)	0.883	4.0	126.5	400 (6)	+		+	Irritates Eyes, Nose, Throat
Carbon Tetrachloride	Tetrachlormethane	(Non-Inflam.)			1.60	5.3	76.8	100 (7)			+	Irritates Nose, Eyes, Throat, Numbness, Liver Damage
Chlorobenzene	Monochlorobenzene			(F.P.-81 F)	1.106	3.8	132.	75 (14)	+	+	+	Acute Narcotic, Chronic Headache, Giddiness
Ethanol	Alcohol	2.3	19.0	15.7	0.789	1.6	78.	250 (8)	+		+	Excitation, Intoxication
Ethyl Ether	Ether	2.3	6.15	3.85	0.708	2.55	34.4	400 (9)	+	+	+	Anesthetic, Irritant, Narcotic
Ethylene Dichloride	Dutch Liquid	6.2	15.9	9.7	1.25	3.42	83.5	100 (10)			+	Dizziness, Nausea, Narcosis, Giddiness
Gasoline		1.5	6.0	4.5	0.747	3.4	50-140	1000 (19)	+	+	+	Intoxication, Narcotic
Methanol	Wood Alcohol	6.7	36.5	29.8	0.793	1.1	64.	100 (20)	+		+	Nerve Poison, Irritant, Dizziness, Blindness
Naphtha	Stoddard Solvent	1.2	6.0	4.8	0.788	4.9	156.	5000 (21)	+	+	+	Intoxication, Narcotic
Perchlorethylene	Tetrachlorethylene	(Non-Inflam.)			1.608	5.72	122.	100 (11)			+	Similar to Trichlorethylene, but less Toxic
Tetrachlorethane	Westron	(Non-Inflam.)			1.60		130.5	10 (13)			+	Narcotic, Liver Damage, Irritation, Headache
Trichlorethylene	Westrosol	(Non-Inflam.)			1.46	4.5	86.7	100 (16)			+	Nervous Disturbances, Dizziness
Toluene	Toluol	1.3	6.8	5.5	0.866	3.2	111.	100 (15)	+			Fatigue, Dizziness, Slight Blood Changes
Turpentine	Spirits of Turpentine	0.8		(F.P.-95 F)	0.860		116.7	200 (17)	+		+	Irritation, Headache, Renal Disturbances
Xylene	Dimethylbenzene	1.0	6.0	5.0	0.88	3.68	139.	100 (18)	+	+		Fatigue, Dizziness, Slight Blood Changes

[a] *Note: Recommended by following states:* (1) Cal., Colo.; (2) Cal., Colo., Kan., Ky., Mass., Minn.; (3) Cal., Colo., Kan., Mass., Minn., Okla.; (4) Cal., Colo., Conn., Penna., S. C.; (5) Cal., Colo., Kan., Okla.; (6) Cal., Colo. Kan., Ky., Mass., Minn., Okla., Penna., Wis.; (7) Cal., Colo., Conn., Kan., Ky., Md., Mass., Minn., Okla., Penna., S. C., Wis.; (8) Cal., Colo.; (9) Cal., Colo., Kan., Mass., Mich., Minn., Okla., Wis.; (10) Cal., Colo., Kan., Mass., Mich., Minn., Okla., Wis.; (11) Mich.; (12) Mich.; (13) Cal., Colo., Kan., Ky., Mass., Minn., Okla., Wis.; (14) Cal., Colo., Kan., Mass., Minn., Okla., Wis.; (15) Cal., Colo.; (16) Mich.; (17) Kan., Mass., Mich., Minn. Okla., Wis.; (19) Cal., Colo., Conn., Kan., Ky., Md., Mass., Minn., Okla., S. C., Wis.; (20) Cal., Colo., Conn., Ky., Md., S. C.; (21) Cal., Colo.

from 100 to 1100 ppm for periods ranging from two weeks to more than five years, Greenburg et al[10,11] found that: (1) Exposure of human beings to toluene resulted in enlargement of the liver in 30.2 per cent, perforated nasal septa (probably due to zinc chromate) in 4.7 per cent of the men, (2) erythrocyte counts were low, 17 per cent below 4.5 million erythrocytes per cubic millimeter of blood, (3) hemoglobins were high, having 16 gm or more per 100 cc of blood, (4) absolute lymphocyte counts high, although differentials were normal, and (5) mean corpuscular volume was high.

Von Oettingen, et al,[12] suggest a maximum permissible concentration for an 8 hour day as 200 ppm for toluene. In operations where specific accident hazards exist this may be too high.

As a control in the nitration of toluene, the nitrators are enclosed and connected to an acid recovery plant by means of a local exhaust ventilation system. Nitrators are maintained under negative pressure sufficient to prevent the escape of toxic vapors into the room atmosphere during the nitration cycle.

Carbon Tetrachloride ($C\,Cl_4$) Tetrachlormethane: Carbon tetrachloride is a heavy, volatile incombustible solvent and extractant for fats and oils. Because of its incombustibility it is used extensively in drug, chemical, rubber, paint, rubber cement and textile soap manufacture.

Twenty-five per cent carbon tetrachloride is used with a cutting compound in the critical tapping and machining operation of a gun plant. As an efficient substitute, 8 per cent, less toxic, trichlorethylene was substituted.

According to the United States Public Health Service,[13] the cause of illness among 135 employees in a Kentucky plant manufacturing parachutes was traced to carbon tetrachloride used in the cleaning of soiled spots on the *chutes*. First symptoms noted began coincidental with the beginning of the heating season and consequent reduction of ventilation in an effort to conserve fuel. The cleaning of these nylon parachutes is now being done with mild soap and water.

Solvent vapors of carbon tetrachloride are given off when tracer and igniter mixtures are charged into the copper jackets in explosive manufacturing. As precautionary measures the following are effec-

Table 2—Toxic Control by Standard Engineering Methods

	ENGINEERING METHODS OF CONTROL						
SOLVENT	1 SUBSTITUTION WITH LESS TOXIC MATERIAL	2 ISOLATION OF PROCESS	3 DILUTION WITH UNCONTAMINATED AIR	4 RESPIRATORY PROTECTION	5 PROTECTIVE CLOTHING	6 LOCAL EXHAUST	7 MAINTENANCE, HOUSEKEEPING AND EMPLOYEE ENLIGHTENMENT
Acetone	E[a]	D	A			B	C
Amyl Acetate	E		A	B	D		C
Aniline	A	C			D	B	E
Benzene	A	D	C			B	
Benzine		B	A		D		C
Butanol	E	B	C			A	D
Butyl Acetate			A	B	D		C
Carbon Tetra.	A	C		D	E	B	
Chlorobenzene	A	C	D			B	E
Ethanol		B	A	E		D	C
Ethyl Ether		A	B	E		D	C
Ethylene Dichloride	A	C	D			B	E
Gasoline		A	C		E	B	D
Methanol	A	C	D	E		B	
Naphtha		E	B		A	D	C
Perchlorethylene		B	A			C	D
Tetrachlorethane	A	C		E		B	D
Trichlorethylene	E	A	C			B	D
Toluene	B	D	C	E		A	
Turpentine		E	A	D		B	C
Xylene		C	A	D		B	E

[a] *Note: Choice of Method:* "A," First choice; "B," Second choice; "C," Third choice; "D," Fourth choice; "E," Fifth choice.

tive: (1) sufficient general ventilation be provided, and (2) charging machines and dies be cleaned with either trichlorethylene, ethyl alcohol or coal oil instead of carbon tetrachloride.

In the centrifugal removal of carbon tetrachloride from degreased objects, control is best effected by enclosing the centrifuge and exhausting the enclosure at a minimum of 100 cfm per square foot of enclosure opening.

Based upon 11 typical plants investigated, Elkins[14] believes the toxic limit of 100 ppm for carbon tetrachloride is too high. He suggests 25 to 50 ppm.

Smyth, et al,[15] state that 50 to 80 ppm of carbon tetrachloride are detectable by odor by the average individual.

When carbon tetrachloride is used openly, as in a shop, ample ventilation should be provided and approved respiratory protection be furnished each man. Skin contact should be avoided.

Gasoline: Gasoline, because of its convenience and traditional usage, is used extensively for washing hands and arms. However, sufficient precautions are not taken to see that the gasolines used do not contain tetraethyl lead. Even as a good substitute for ordinary gasoline for washing and cleaning purposes, mineral seal oil, mineral spirit or various grades of naphtha may be recommended.

According to Humperdinck,[16] German gasoline contains an average of 0.8 cc of ethyl fluid per liter. The fluid is composed of 63.0 per cent lead tetraethyl, 25.8 per cent ethylene dibromide, 8.7 per cent ethylene dichloride and 2.5 per cent coloring matter. Volatility is sufficient at normal temperatures to produce a concentration of 5 milligrams of lead per liter of air.

Serious exposures to lead are encountered in the spray cleaning with leaded gasoline of airplane motors after they have been tested. The use of tetraethyl gasoline for this purpose should be prohibited. Spray cleaning should be done in a small room, cabinet or booth provided with mechanical exhaust ventilation rate at a minimum of 150 cfm per square foot of room cross-sectional area or booth opening. As an added precaution the operator should remain always in the clean air upstream of the motor.

Degreasing Solvents: The chlorinated compounds of petroleum, because of their non-inflammable nature and strong solvent action, are the most widespread solvents used in the degreasing of metals. The two principal ones today finding extensive use for this purpose are trichlorethylene (Perma-achlor, Triad, Tromex, Blacosolv), and perchlorethylene (Phillsolv, tetrachlorethylene).

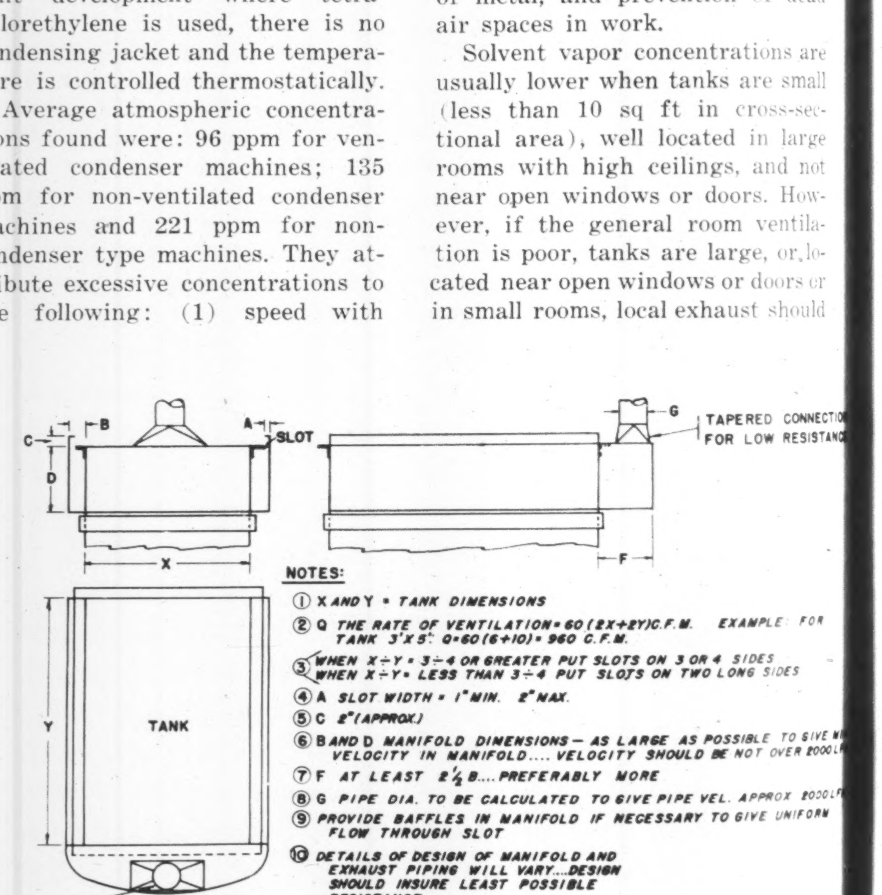
Degreasing is usually accomplished by the dipping, wiping, vapor, vapor spray, hot liquid-vapor or hot liquid-cold-cold-liquid vapor processes.

Based upon an engineering study of 108 degreasers, Morse and Goldberg[17] state that degreasing liquid cleans metal parts by (1) immersion, (2) spraying, or (3) vapor. Ninety per cent of all degreasers use two or more methods. According to the authors, degreasers consist of a tank with a heating unit and condensing jacket, but in a recent development where tetrachlorethylene is used, there is no condensing jacket and the temperature is controlled thermostatically.

Average atmospheric concentrations found were: 96 ppm for ventilated condenser machines; 135 ppm for non-ventilated condenser machines and 221 ppm for non-condenser type machines. They attribute excessive concentrations to the following: (1) speed with which work is lowered into and removed out of the machine (manufacturers recommend 12 fpm), (2) cooling beyond the dew-point temperature of the room, causing condensation and addition of water to the solvent, thereby lowering its boiling point, (3) not keeping work in the vapor zone until condensation stops, (4) poor arrangement of work in basket, (5) lack of temperature control of circulating water, which should be below 110 F, and above all (6) operation by inexperienced and unintelligent workers.

They recommend: hoists set at a maximal speed of 20 fpm and withdrawal of work at same speed; equipment with thermostatic control of heating and condensing zones; proper design of basket; location of tanks in as large an area as possible, maintaining a minimum operative area exposed to air, a minimum freeboard distance of 0.6 of the tank width, careful maintenance of heat balance with every change in type and weight of metal, and prevention of dead air spaces in work.

Solvent vapor concentrations are usually lower when tanks are small (less than 10 sq ft in cross-sectional area), well located in large rooms with high ceilings, and not near open windows or doors. However, if the general room ventilation is poor, tanks are large, or located near open windows or doors or in small rooms, local exhaust should


C
B
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TAPERED CONNECTIO
FOR LOW RESISTANC
X
F
Y
TANK
NOTES:
① X AND Y = TANK DIMENSIONS
② Q THE RATE OF VENTILATION = 60 (2X+2Y) C.F.M. EXAMPLE: FOR TANK 3'X5': Q=60 (6+10) = 960 C.F.M.
③ WHEN X÷Y = 3÷4 OR GREATER PUT SLOTS ON 3 OR 4 SIDES
WHEN X÷Y = LESS THAN 3÷4 PUT SLOTS ON TWO LONG SIDES
④ A SLOT WIDTH = 1" MIN. 2" MAX.
⑤ C 2" (APPROX.)
⑥ B AND D MANIFOLD DIMENSIONS — AS LARGE AS POSSIBLE TO GIVE MI
VELOCITY IN MANIFOLD.... VELOCITY SHOULD BE NOT OVER 2000 L
⑦ F AT LEAST 2½ B.... PREFERABLY MORE
⑧ G PIPE DIA. TO BE CALCULATED TO GIVE PIPE VEL. APPROX 2000 LF
⑨ PROVIDE BAFFLES IN MANIFOLD IF NECESSARY TO GIVE UNIFORM FLOW THROUGH SLOT
⑩ DETAILS OF DESIGN OF MANIFOLD AND EXHAUST PIPING WILL VARY....DESIGN SHOULD INSURE LEAST POSSIBLE RESISTANCE
⑪ GAS-HEATED TANKS SHALL HAVE COMBUSTION CHAMBER INDEPENDENTLY VENTILATED TO OUTSIDE THRU NON-CORROSIVE VENT PIPE
CONNECTION TO EXHAUST PIPE AND FAN TO OUTSIDE
103

Fig. 3—Ventilation of degreasing tank

be provided by means of slot-type, lateral exhaust hoods located along one or both long sides of the tank at the upper edge (see Fig. 3). The minimum effective exhaust ventilation rate is computed as follows: $Q = 50\ LW$; where Q is the exhaust ventilation rate in cubic feet per minute; L is the length of the tank in feet; and W is the width of the tank in feet. Remedial measures are indicated: if the atmospheric concentration of trichlorethylene is more than 200 ppm; if the solvent consumption is more than 2 gal per square foot of tank area per 100 lb of operation, or if the odor of trichlorethylene is distinctly noticeable.

Small amounts of aniline have recently been added to commercial degreasing solvents as a substitute for the triethylamine which serves as a stabilizer. In view of the high toxicity of aniline, greater care must be exercised.

In some cases attributed to solvent poisoning recently appearing in the literature,[18] the workers so affected were engaged in cleaning a degreasing tank without proper breathing apparatus or life belts.

An unusual trichlorethylene fatality reported in England[19] involved a night watchman in Birmingham, who tried to dry-clean his trousers by dipping them in industrial trichlorethylene. After taking the trousers into a shelter with him, turning on an electric radiator and going to sleep, he was killed by the vapor.

Reference again to Table 1 shows a few additional, very interesting solvents which the Army is called upon to find practical means of controlling. Fortunately the backlog of valuable information accumulated in the past on how to keep workers well is a most treasured non-secret weapon available with which to do the job at hand. Generally speaking, from an engineering point of view, it might be added with a measured amount of confidence that few, if any, of the problems encountered have failed to yield their hazardous status to good, sound, practical, common sense applications.

Selection of Toxic Control Method

Table 2 will be useful in selecting a toxic control procedure. Various methods are shown in the order of their preference and desirability.

Table 3—Types of Canister for Protection Under Various Conditions
(Gas Masks)

CONDITIONS	CONTENTS OF CANISTER	COLOR OF CANISTER
(1) Protection against organic vapors, such as aniline, gasoline, benzene, ether, toluene, and the like (when not over 20 per cent in air).	600 cu milliliters or more of activated charcoal.	Black
(2) Protection against acids such as hydrochloric, sulphur dioxide, nitrogen peroxide, chlorine and the like (not over 1 per cent in air).	600 cu milliliters or more of soda lime or fused caustic soda.	White
(3) Protection against ammonia gas not over 3 per cent. The 3 per cent limit cannot be long endured by the wearer because of the skin irritation from the gas.	Copper sulfate and charcoal.	Green
(4) Protection against carbon monoxide (not over 3 per cent).	A mixture of metallic oxides known as *hopcalite* which catalizes the combustion of carbon monoxide with oxygen from the air and produces carbon dioxide.	Blue
(5) Protection against all of the above gases; the *all service mask*.	All of the absorbents mentioned above, but only small amounts of each.	Red
(6) Protection against a combination of organic fumes and acid fumes.	Activated charcoal and soda lime.	Yellow
(7) Protection against ammonia and smoke.	Copper sulfate and charcoal with a filter pad for smoke.	Brown
(8) Protection against hydrocyanic acid gas (not over 2 per cent).	Caustic soda impregnated on pads.	With a green stripe.

When gas masks are used for respiratory protection, canisters must contain absorbents for the toxic gases encountered. Standard markings for gas mask canisters which indicate their contents and protective ability are shown in Table 3.

Conclusion

In closing this discussion there are three points that cannot be over-emphasized:

(1) Industrial solvents, generally speaking, are capable of entering the human body by skin absorption as well as by mouth or inhalation. In attempting control, therefore, all these vital possibilities should be considered by the engineer.

(2) In addition to knowing the physical, chemical, corrosive or explosive properties, the engineer must familiarize himself with the *chronic* as well as acute toxic results anticipated from ignorant excessive use of these substances.

(3) That all solvents, regardless of their toxicity, unless proven otherwise, irrespective of their mode of entry into the human organism, are foreign to the metabolic function and as such contribute no end to the accident proneness of the individual.

With the foregoing thoughts borne uppermost in the mind of the engineer, the solution of one of the major problems directly affecting the conservation of manpower in war industries will be relatively simple. "Death Without Battle," to borrow the title from a recent Army educational "skit," insofar as applied to solvent hazards, will be an expression relegated to the Sargasso Sea of obsolescence.

Acknowledgment

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FATALITIES WITH BREATHING DEVICES

In reviewing case histories of fatal accidents to men while wearing oxygen breathing apparatus, the Bureau of Mines has concluded that the safe use of self-contained oxygen breathing devices, commonly called *mine-rescue apparatus*, in atmospheres not capable of sustaining life is dependent upon three highly important factors: well-trained, physically fit personnel; properly functioning equipment of an approved design; and competent direction of a safe and sound procedure.

Dr. R. R. Sayers, Bureau of Mines Director, reported to Secretary of the Interior Harold L. Ickes that thousands of men have been trained in the use and care of this apparatus since its introduction to the United States about 35 years ago, and hundreds of units of self-contained oxygen breathing apparatus have been used successfully in rescue and recovery work following mine accidents.

Do's and *don'ts* in the use of mine-rescue apparatus are listed in a new Information Circular 7279. As stated in the circular, properly trained crews of five or six men each have been able to utilize this equipment without mishap for periods of from several hours to several months in connection with rescue or recovery work following mine fires or explosions.

The Bureau's study of these cases was compiled by G. W. Grove, Supervising Engineer, District "A," Health and Safety Service, Bureau of Mines, Pittsburgh, Pa.

NEW CHAPTERS ORGANIZING

Denver

At the April Council meeting permission was granted to Denver, Colo., members to establish a Rocky Mountain Chapter of the Society. The first meeting of the group was held April 22, at the Cosmopolitan Hotel, Denver, with Pres. S. H. Downs as the principal speaker. B. G. Peterson, President of the Omaha Chapter, served as chairman pro-tem of the organizing group, which included 28 men. Frank L. Adams of Public Service Co. of Colorado was appointed permanent chairman of the Chapter Organizing Committee, assisted by H. H. Herman, G. D. Mayes, J. H. McCabe and Keith F. Ebey.

Columbus

On May 1 at the Deshler-Wallick Hotel, Columbus, Ohio, 17 ASHVE members and guests met to discuss the possibility of establishing a Central Ohio Chapter of the Society. Merrill F. Blankin, past president of the Society and chairman of the Membership Committee, Brig.-Gen. W. A. Danielson, Memphis, a member of Council, A. V. Hutchinson, secretary of the Society, and George Sutfin and A. W. Edwards, officers of the Cincinnati Chapter, were present and addressed the meeting.

J. D. Slemmons was elected chairman and Allen W. Williams as secretary of the organization group, and the following Organizing Committee was appointed: H. B. Allonier, R. B. Breneman, R. B. Engdahl, W. M. Myler, Jr., and D. H. Wyatt.

A second meeting of the group was held on May 15 at the Seneca Hotel, with 19 present, and it was voted to prepare an application for a Chapter for submission to Council of the Society.

Memphis

On March 15, at the Peabody Hotel, Memphis, 11 members and guests met with Brig.-Gen. W. A. Danielson, member of the Council, and A. V. Hutchinson, secretary of the Society, to make a preliminary survey of the membership possibilities in Memphis, and it was agreed, at a meeting on April 3 at the Army Service Forces Depot, that the organization of a chapter with headquarters in Memphis was desirable. General Danielson called the meeting to order and J. J. Nolan was elected temporary chairman, with W. E. Thorpe as temporary secretary.

An Organizing Committee was appointed consisting of E. G. Woodson, chairman; L. M. Barlow, vice-chairman; F. H. Bigelow and H. C. Donnelly.

At a meeting on April 24, at the Peabody Hotel, J. J. Nolan presided, and Axel O. Fabrin gave an interesting talk on the development of deep wells and water-pumping problems, particularly related to comfort cooling and industrial air conditioning. The meeting was attended by 20 members and guests.

Salt Lake City

During a visit to Salt Lake City on April 20, Pres. S. H. Downs addressed a group of members and guests interested in the organization of a Salt Lake Valley Chapter of the Society. Arrangements for the meeting were made by B. F. McLouth and resulted in the filing of a petition for a chapter charter.

Description and Performance of Two Heat Pump Air Conditioning Systems

(Using Well Water and Outside Air as the Heat Source)

By Philip Sporn* and E. R. Ambrose,** New York, N. Y.

SUMMARY—Description of two year 'round air conditioning systems operating on the heat pump principle, one using water and the other air as a heat source. Similarity of weather conditions for both installations affords an opportunity for comparison of operation and performance.

SINCE THE installation of the heat pump system at the Atlantic City Electric Company's office building, Salem, N. J.,[1] six other such systems have been installed on the properties of the subsidiaries of the American Gas and Electric Co.[2] The Ohio Power Company's office building systems at Portsmouth and Coshocton, Ohio, were selected for the subject of this paper, partly because of their unusual design, but mainly because the source of heat is air in one case and water in the other, thus offering an opportunity to compare the operation and coefficient of performance of two different heat source systems of the latest design which are located in approximately the same sections of the country.

Buildings

The Ohio Power Company's office building, Coshocton, Ohio, erected in 1940, has two stories and a basement, and is 88 ft long by 55 ft wide by 35 ft high.

The Ohio Power Company's office building, Portsmouth, Ohio, also erected in 1940, has four stories and is 104 ft long by 45 ft wide by 45½ ft high. Since this building is located in a flood area, no basement was provided. The fourth story was designed for equipment usually found in a basement and contains the air-conditioning room, transformer vault, telephone switching room and general storage vault.

Both buildings are of non-combustible construction with reinforced concrete foundation. Floor construction consists of reinforced concrete on open web joists and the roof consists of steel plate deck similarly supported. The space between the floor slab and the ceiling of the floor underneath was designed to afford the free movement of air and is used as an air return plenum for the heat pump systems. In general, all the interior walls and the ceilings above the first floor are plastered. The ceilings of the first story have acoustic tiles and all the floors are covered with asphalt tile.

All windows are fixed and have double glazing. The exterior walls for the Coshocton building consist of 4-in. face brick backed up by 8 in. of clay terra-cotta blocks. In the Portsmouth building the exterior walls, up to the flood level, were made of solid masonry and lined with ceramic glazed block to make it water resistant. Above the flood level, 13 in. of brick was used with a plastered finish. One inch of rigid insulation was applied on the inside of all exterior walls in both buildings and 1 in. on the roofs at Portsmouth and 2 in. at Coshocton.

Fig. 1 is a west view of the Coshocton office building showing the main entrances. Fig. 2 is a view of the heat pump equipment room located in the basement of the Coshocton office building, showing the two compressors, some of

Fig. 1—Office building of The Ohio Power Company, Coshocton, Ohio—West view

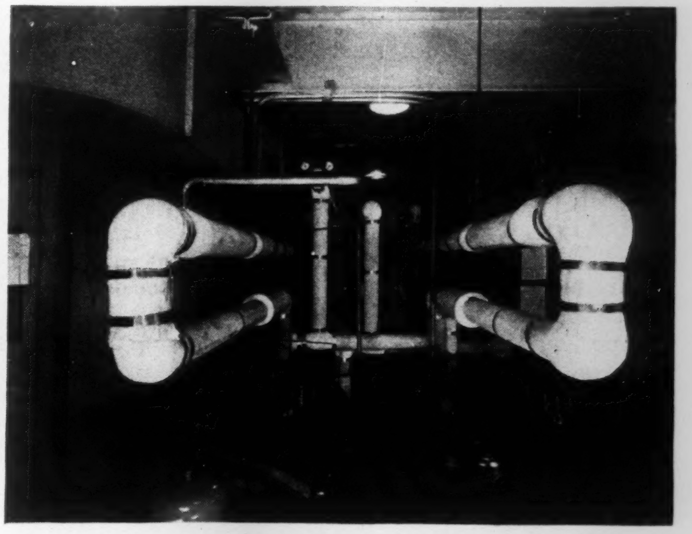

Fig. 2—Refrigerant compressors and connecting piping, Coshocton system

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*Vice President and Chief Engineer, American Gas and Electric Service Corp.

**Air Conditioning Engineer, American Gas and Electric Service Corp. Member of ASHVE.

[1] An All Electric Heating, Cooling and Air Conditioning System (Installation and Performance of Plant Using the Heat Pump Principle), by Philip Sporn and D. W. McLenegan. (ASHVE Transactions, Vol. 41, 1935).

[2] The Heat Pump (An All-Electric Year-Round Air-Conditioning System), by Philip Sporn and E. R. Ambrose. (*Heating and Ventilating*, Vol. 41, No. 1, January 1944.)

For presentation at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Grand Rapids, Mich., June 1944.

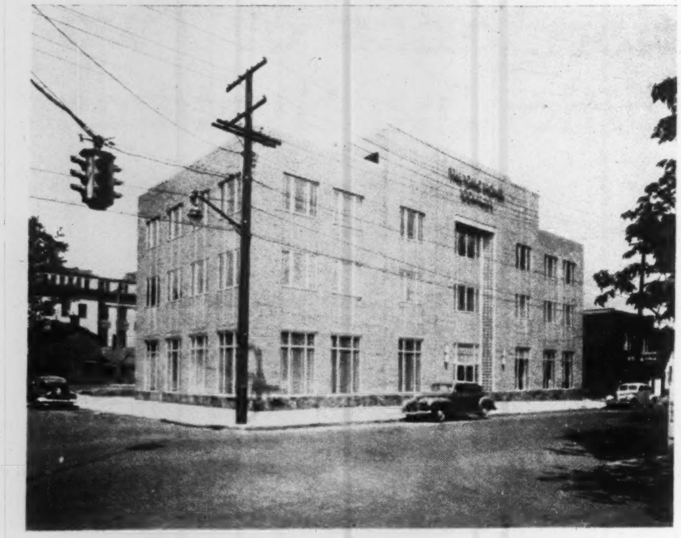


Fig. 3—Office building of The Ohio Power Company, Portsmouth, Ohio—East view

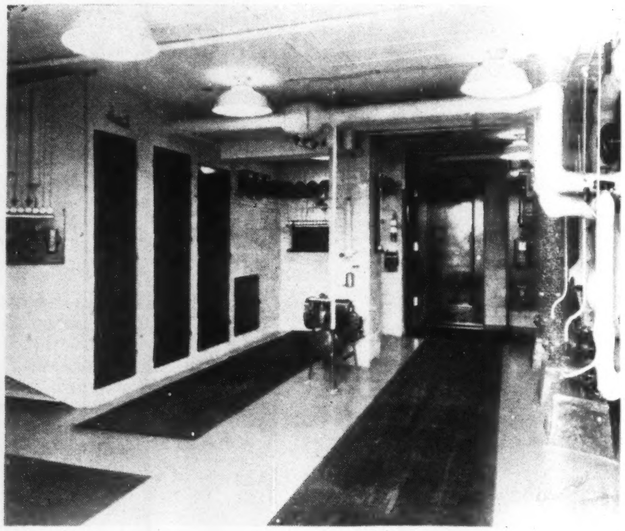


Fig. 4—Air conditioning equipment room, fourth floor, Portsmouth building

the refrigerant and water piping, the 3-way valves, the conditioner housing and the pneumatic control panel. Fig. 3 is an east view of the Portsmouth building showing the main entrance. The second and third floors are divided into various individual offices.

Figs. 4 and 5 are views of the fourth floor air conditioning equipment room of the Portsmouth building showing the refrigerant compressors, control panel, air conditioner housing, outside air unit, condenser, cooler and connecting piping.

The liquid circulating pump is shown in the foreground of Fig. 5 and the "Freon" refrigerant system and liquid piping in the background. The electric control panel is at the left. The air conditioner housing and the pneumatic control panel are shown at the left in Fig. 4.

Design Temperature Limits

The climatogical data, as published by the U. S. Department of Agriculture, was studied for a five-year period to determine the minimum and maximum temperature which would be encountered during the heating and cooling seasons at the two locations. Based on this study, —5 F and 0 F were selected as the probable average minimum outdoor temperatures which would be encountered during the heating cycle at Coshocton and Portsmouth, respectively, and 95 F dry-bulb and 75 F wet-bulb as the average maximum temperature encountered during the cooling cycle. For both systems an inside temperature of 72 F and 30 per cent relative humidity was selected for the heating season and 78 F and 50 per cent relative humidity during the cooling season.

Using the foregoing selected design temperatures, the heat gain and heat loss calculations for Coshocton (Table 1) were about equal, figure 404,700 Btu per hour heat gain and 409,700 Btu per hour heat loss, while in the case of the Portsmouth building (Table 2) the heat gain was 450,000 Btu per hour and the heat loss 354,700 Btu per hour.

After the heat gain and heat loss calculations are made, consideration can be given to the economical selection of the equipment. Usually the best method is to base the sizing of the compressors, coils and other equipment on the heat gain and using this selection determine the heat output at various outdoor temperatures. Following this procedure, the resulting heat output will be found to be sufficient to satisfy the heat loss for most installations. This was the case in Coshocton, where the temperature of the heat source is constant and independent of the outdoor temperatures, thus allowing the refrigerating compressors to operate at approximately the same suction pressure during both the heating and cooling cycle. However, this is not the case in an air system such as Portsmouth. Here, as the outdoor temperature drops the suction pressure of the compressors is lowered, resulting in a proportional reduction in capacity. This necessitates,

Fig. 5—Air conditioning equipment room, fourth floor, Portsmouth building

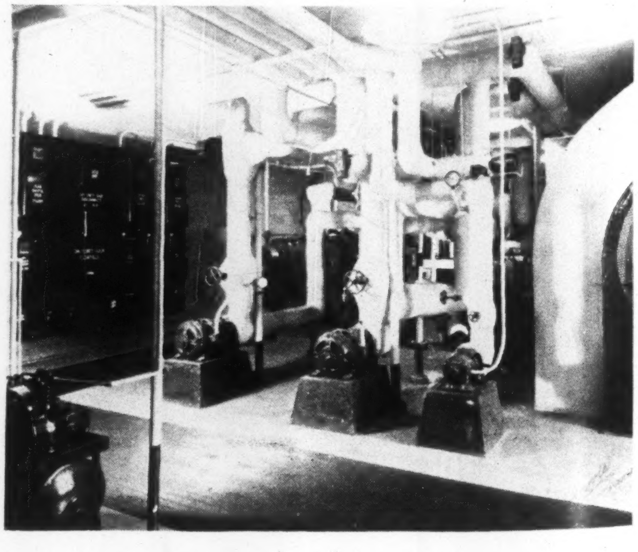


Table 1—Heat Gain—Heat Loss Calculations Coshocton Building

	HEAT GAIN BTU/HR AT 78 F-50 PER CENT R.H. INSIDE 95 F D.B.-75 F W.B. OUTSIDE	HEAT LOSS BTU/HR AT 72 F-30 PER CENT R.H. INSIDE —5 F OUTSIDE
Sensible		
Conduction	26,600	206,700
Solar radiation	103,000	......
Light	128,000	......
Ventilation air	39,600	203,000
People	32,000	......
Latent		
Ventilation	38,000	......
People	37,500	......
Total	404,700	409,700

Table 2—Heat Gain—Heat Loss Calculations Portsmouth Building

	HEAT GAIN BTU/HR AT 78 F-50 PER CENT R.H. INSIDE 95 F D.B.-75 F W.B. OUTSIDE	HEAT LOSS BTU/HR AT 72 F-30 PER CENT R.H. INSIDE 0 F OUTSIDE
Sensible		
Conduction	40,000	203,700
Solar radiation	82,500	......
Light	181,500	......
Ventilation air	31,800	151,000
People	44,200	......
Latent		
Ventilation air	30,400	......
People	39,600	......
Total	450,000	354,700

in most cases, an auxiliary heat source or some form of booster heaters during the lower outdoor temperatures.

In the case of the Coshocton system, it can be seen from the heat gain-heat loss tabulation that if the mechanical refrigeration equipment had been sized to remove the entire heat gain, the output during the heat cycle would have considerably exceeded the requirements for the coldest day. To remedy this condition, a well water precooling coil was utilized to absorb 120,000 Btu per hour, thereby reducing the mechanical refrigeration equipment and still satisfy the cooling requirement. Since the 10 ton reduction in the mechanical refrigerating equipment caused the heating capacity to be slightly undersized for the coldest days, a 15 kw electric heater was incorporated as a safety measure to act as a booster during these periods. It is interesting to note that in almost three years' operation of this plant no call has been made on this auxiliary heat source.

For the Portsmouth system, the equipment selected on the basis of heat gain requirements was found to have sufficient capacity to satisfy the heating requirement when the outdoor temperature was 20 F or above. For outdoor temperatures below 20 F city water is used as the heat source.

The Systems

The conditioned air is distributed to the several zones in each of the two buildings by means of galvanized iron ducts. The air is returned through grilles located in the outside walls near the floor (usually underneath the windows), which connect to the plenum between floor and ceiling by means of wall chases as shown in Fig. 6. These plenums open into a vertical shaft which in turn connects to the conditioner housing located in the equipment room.

A *blow through* type conditioning unit was employed on both the Coshocton and Portsmouth systems. In this design the air circulating fan delivers the outside-recirculated air mixture through the filters, then over the heating and/or cooling coils into one of two plenums. The zone thermostats, by controlling the operation of the two dampers, regulate the amount of air flowing from each of the two chambers into the zone supply duct.

The conditioning unit for the Coshocton building (Fig. 7) consists of a heating coil and humidifier in one plenum and a well water precooling coil and a mechanical refrigeration coil in the other. Due to the possibility of having a large crowd of people in the auditorium, an additional dehumidifying coil was installed in the supply duct to this zone to take care of the high latent heat load.

Fig. 8 shows the conditioning unit for the Portsmouth office building. The bypass coil in this unit serves as a supplementary heating or cooling coil, as required. The main difference between the two units is the use of a separate heating and cooling coil at Coshocton while one coil serves at Portsmouth.

The unit used to absorb the heat from the outdoor air at Portsmouth is shown diagrammatically in Fig. 9. It consists of a coil, automatic intake and exhaust dampers, circulating fan and sprays. During normal operation the air is taken from the outside, over the coil, where heat is given up to the circulating medium, then discharged by the fan back to the outside. When the outdoor temperature falls below 20 F, the circulating fan is shut down, the intake and exhaust dampers closed, and a continuous flow of city water is sprayed over the coil, in which case all heat absorbed by the system is taken from the city water. During the cooling cycle the spray-coil combination is used as an evaporative condenser.

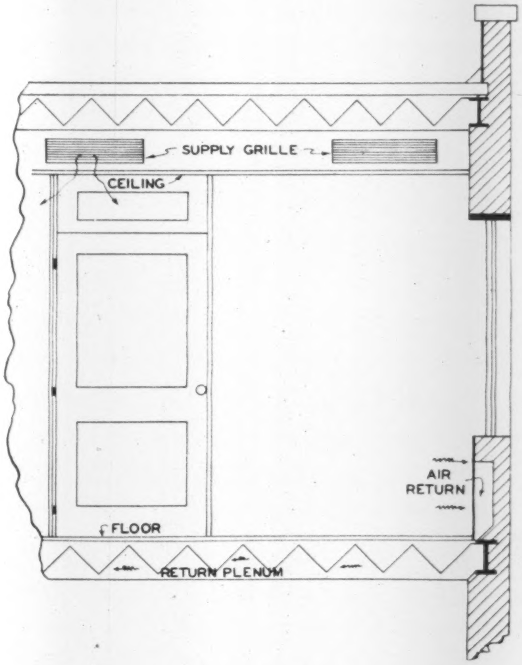


Fig. 6—Cross-section through Portsmouth building, showing supply and return grilles

Piping

The designs at Coshocton and Portsmouth are commonly known as indirect systems, since a liquid is used to transfer the heat from an outside medium to the refrigerant. Water is used as this liquid at Coshocton because the temperature need never go below 32 F while at Portsmouth Super Pyro anti-freeze solution is employed since it is necessary that the temperature of the liquid be below the freezing temperature of water when the outdoor temperature is 32 F or below. In an indirect system the refrigerant circuit, shown by Fig. 10, for the Portsmouth system is fixed, going from the compressor to the condenser, through the heat exchanger, float valve and cooler, then through the heat exchanger back to the compressor.

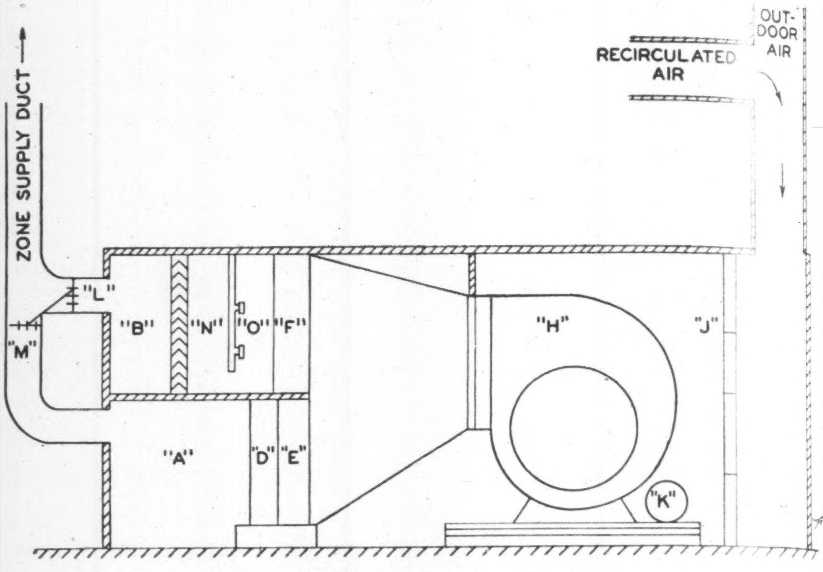


Fig. 7—Conditioning unit at Coshocton

"A" Cold air plenum
"B" Warm air plenum
"D" Cooling coil
"E" Pre-cooling coil
"F" Heating coil
"H" Fan
"J" Filters
"K" Fan motor
"L" Damper
"M" Damper
"N" Eliminator plates
"O" Humidifying sprays

In the Portsmouth system the humidifier water is heated by the refrigerant gas by means of a heat exchanger, while at Coshocton the heated water is taken directly from the system. The Portsmouth compressors are each equipped with 50 per cent modulation valves, shown diagrammatically in Fig. 10, making possible 25, 50, 75 or 100 per cent capacity modulation. This capacity modulation consists in allowing a portion of the refrigerant gas to go directly from the discharge to the suction side of the compressor, thus reducing the amount of refrigerant being circulated through the system. A solenoid valve installed in this bypass line controls the amount of gas which is passed through the circuit. The capacity modulation on the Coshocton system is provided by starting and stopping either one or both compressors.

When the systems are on the heating cycle, the bypass coil in the Portsmouth system and the cooling coil at Coshocton can furnish cooling simultaneously to some of the zones while heating is supplied to the others. Conversely, when the systems are on the cooling cycle, the bypass coil in the Portsmouth system and the heating coil at Coshocton can furnish heating while the other coils furnish the required cooling. This feature has proven quite important in these systems, since some of the occupied space has little or no outside exposure, therefore, practically requiring cooling the year 'round, and too during the heating season the auditorium, when in use, usually requires cooling because of the heat gain resulting from the assembly of a large group of people.

Fig. 11 shows the water circuit for the Coshocton system. During the heating cycle the deepwell pump A circulates well water through the circuit consisting of V-4, direction 1-2, water coolers 1 and 2, cooling coils D and G, mixing valve V-3 then through valve V-7, direction 1-2, to the discharge well. The pump B circulates water through closed circuit consisting of V-6, direction 1-2, condensers 1 and 2, heating coil F, valves V-1 and V-5, direction 1-2.

During the cooling cycle deepwell pump A circulates well water through the circuit consisting of V-4, direction 1-3, precooling coil E, condensers 1 and 2, heating coil, mixing valves V-1 and V-5, direction 1-3 to the discharge well. Pump B circulates the water through closed circuit consisting of V-6, direction 1-3, water coolers 1 and 2, coil D, and auditorium coil G, mixing valve V-3, direction 1-3, back to pump B.

Table 3—Actual Performance Data for Coshocton System

	Tests No. 1	 No. 2	 No. 3
Supply Air to Conditioned Space			
Cubic feet per minute	11,000	11,000	11,000
Temperature, degrees Fahrenheit	78.6	80.5	94.3
Outside Air			
Cubic feet per minute	2,500	2,500	2,500
Temperature, degrees Fahrenheit	37	35	35
Conditioner Heating Coil (for location coil F see Fig. 11)			
Entering Water Temperature, degrees Fahrenheit	88	92.8	113.5
Leaving Water Temperature, degrees Fahrenheit	83	87.0	103
Gallons per minute	70	70	70
Water Cooler (see Fig. 11)			
Entering Water Temperature, degrees Fahrenheit	55	55	55
Leaving Water Temperature, degrees Fahrenheit	47	46.5	47.3
Gallons per minute	37	38	75
Electric Consumption			
Compressors, kilowatts	10.2	15.5	27.5
Auxiliaries, kilowatts	5.2	5.2	5.2
Total kilowatts[a]	15.4	20.7	32.7
Capacity			
Refrigeration, Btu/hour	148,000	161,500	288,600
Heat Output, Btu/hour	175,000	203,800	366,600
Coefficient of Performance			
Using Kilowatt Input to Compressors	5.0	3.85	3.9
Using Total Kilowatt Input[b]	3.5	3.0	3.3

Test No.
1— 10 Hp Compressor—120 psi head pressure—40½ psi suction
2— 15 Hp Compressor—140 psi head pressure—35 psi suction
3—(10 Hp Compressor—150 psi head pressure—42½ psi suction
(15 Hp Compressor—175 psi head pressure—38½ psi suction

[a] Kw to conditioner supply fan not included.
[b] 60 per cent of auxiliaries kw input was considered useful heat.

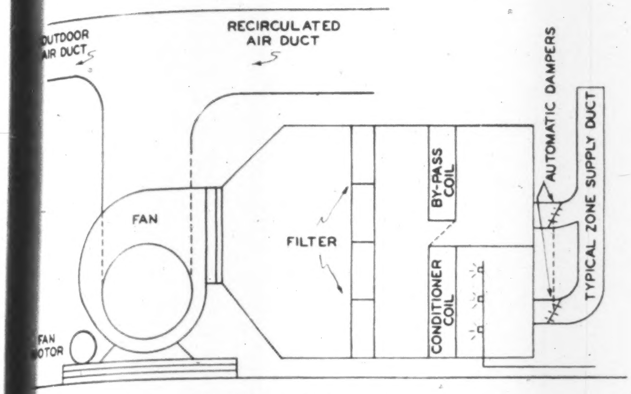

OUTDOOR AIR DUCT
RECIRCULATED AIR DUCT
AUTOMATIC DAMPERS
TYPICAL ZONE SUPPLY DUCT
BY-PASS COIL
FAN
FILTER
CONDITIONER COIL
FAN MOTOR

Fig. 8—Conditioning unit at Portsmouth

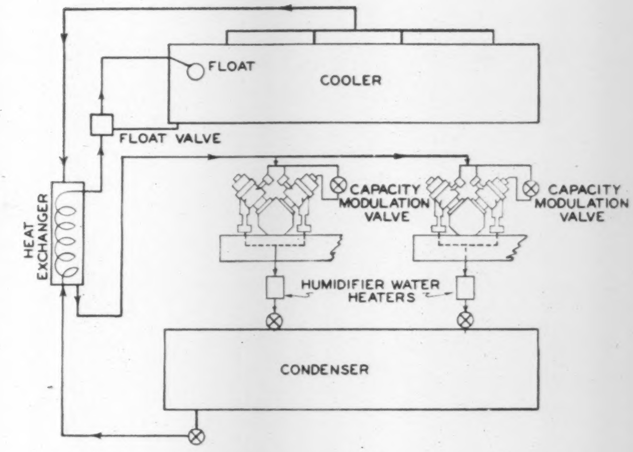

FLOAT
COOLER
FLOAT VALVE
HEAT EXCHANGER
CAPACITY MODULATION VALVE
CAPACITY MODULATION VALVE
HUMIDIFIER WATER HEATERS
CONDENSER

Fig. 10—Refrigerant circuit, Portsmouth system

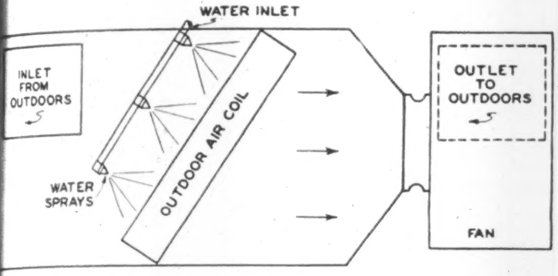

WATER INLET
INLET FROM OUTDOORS
OUTDOOR AIR COIL
WATER SPRAYS
OUTLET TO OUTDOORS
FAN

Fig. 9—Outdoor air unit, Portsmouth system

Fig. 12 shows the circuit for the Portsmouth system. During the heating cycle pump A circuit consists of V-3, direction 1-3, conditioner coil, valve V-4, direction 3-1, and condenser back to pump A. Pump B circuit consists of V-1, direction 1-3, outdoor air coil, V-2 direction 3-1, and cooler back to pump B. Pump C circulates the fluid from the inlet of the outdoor air coil and/or the bypass coil, through V-5, then the bypass coil to the outlet of the outdoor air coil. This furnishes the means of cooling some of the interior zones when the remaining zones require heating. During the cooling cycle pump A circuit consists of V-3 direction 1-2, outdoor air coil, V-4 direction 2-1, and condenser. Pump B circuit consists of V-1 direction 1-2, air conditioner coil, V-2 direction 2-1, and cooler. Pump C circulates the fluid from the inlet of the outdoor air coil and/or the bypass coil, depending on the requirements of the thermostat, through V-5, bypass coil to the outlet of outdoor air coil. This allows heating of some of the exterior zones when the remaining zones require cooling.

Fig. 13 shows the city water circuit for outdoor air unit of the Portsmouth system. During the heating cycle the water to the sprays are controlled by valve V-9. This valve opens in response to outdoor thermostat T-3, shown in Fig. 15. The water to the humidifier, under control of valve V-20, first passes through heaters which are located in the hot gas line from the refrigerating compressor. V-6 is open during this cycle, allowing all water in the drain pan to go to the sewer. During the cooling cycle pump D circulates the water from the drain pan to the sprays. During this cycle valve V-7 allows the make-up water to be under control of the float valve.

Control

Basically the two systems have similar control equipment. The reversing valves, shutoff valves, dampers and thermostats are pneumatically operated from a small motor driven air compressor system and are interlocked with the various electric starting switches controlling the motors. High and low pressure compressor safety switches and low temperature immersion thermostats, to guard against freezing of the cooler, have been incorporated in both designs. Also, all of the controls are interlocked with the fans so that the system is inoperative until the fans start. When the fan push button

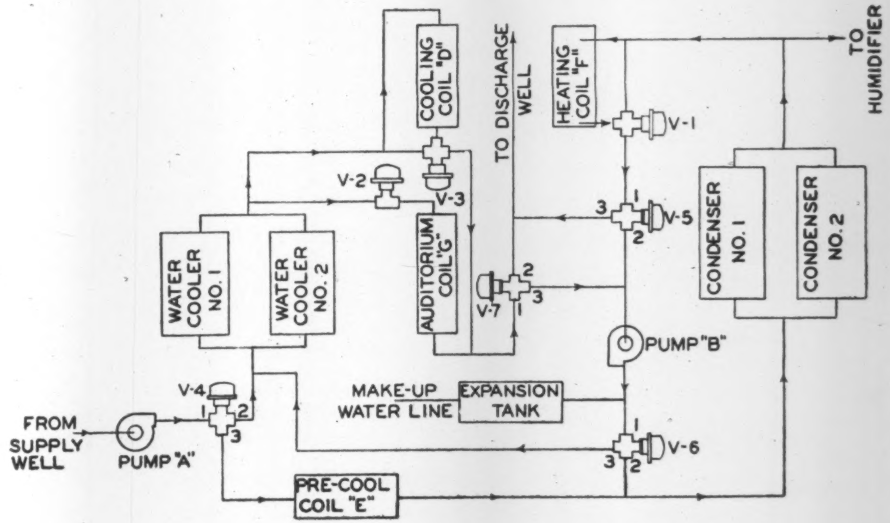
Fig. 11—Water circuit, Coshocton system, showing circulating pumps and reversing valves

HEATING CYCLE

Valve V-4	Position 1-2
Valve V-5	Position 1-2
Valve V-6	Position 1-2
Valve V-7	Position 1-2

COOLING CYCLE

Valve V-4	Position 1-3
Valve V-5	Position 1-3
Valve V-6	Position 1-3
Valve V-7	Position 1-3


COOLING COIL "D"
TO DISCHARGE WELL
HEATING COIL "F"
TO HUMIDIFIER
V-1
V-2
V-3
V-5
AUDITORIUM COIL "G"
WATER COOLER NO. 1
WATER COOLER NO. 2
CONDENSER NO. 1
CONDENSER NO. 2
V-7
PUMP "B"
V-4
MAKE-UP WATER LINE
EXPANSION TANK
FROM SUPPLY WELL
PUMP "A"
V-6
PRE-COOL COIL "E"
1
2
3

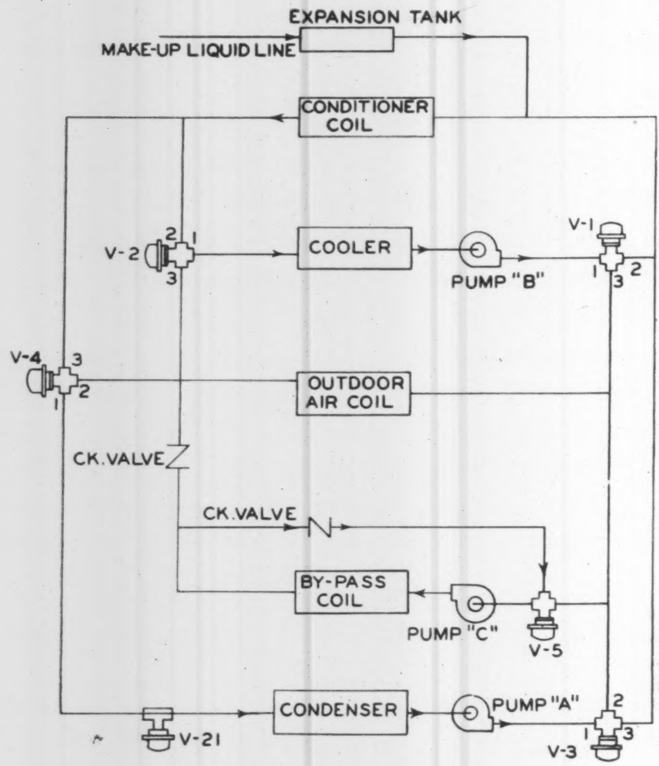

EXPANSION TANK
MAKE-UP LIQUID LINE
CONDITIONER COIL
V-2
COOLER
PUMP "B"
V-1
V-4
OUTDOOR AIR COIL
CK. VALVE
CK. VALVE
BY-PASS COIL
PUMP "C"
V-5
CONDENSER
PUMP "A"
V-21
V-3
1
2
3

Fig. 12—Super pyro circuit, Portsmouth system
Heating cycle—Valve position 1-3
Cooling cycle — Valve position 1-2.

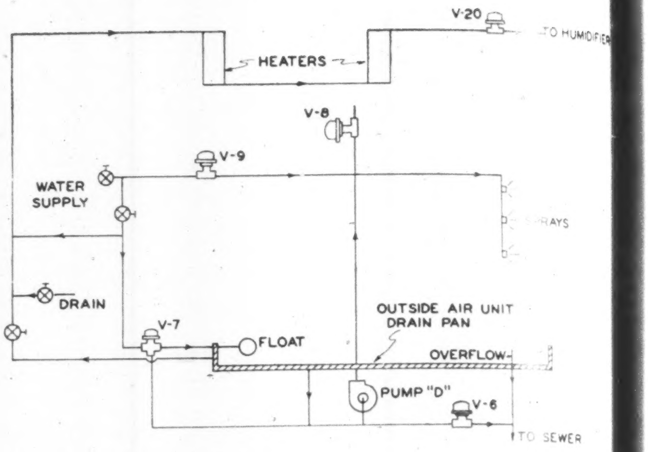

V-20
TO HUMIDIFIER
HEATERS
V-8
V-9
WATER SUPPLY
SPRAYS
DRAIN
V-7
FLOAT
OUTSIDE AIR UNIT DRAIN PAN
OVERFLOW
PUMP "D"
V-6
TO SEWER

Fig. 13—City water circuit when outdoor temperatures are 20 F or below, Portsmouth system

is closed, starting the fans, the operation of both systems is completely automatic. The main difference in control of the two systems is the heating and cooling changeover feature. At Coshocton an outdoor thermostat automatically changes the system to the heating cycle when the outdoor air drops below a predetermined setting and to the cooling cycle when the outdoor temperature rises above the setting; while at Portsmouth two thermostats in the return air duct (set 5 or 6 deg apart) govern the cycle of operation independently of the outdoor temperature.

A—Coshocton System

Fig. 14 shows the pneumatic and electric control diagram for the operation of this system. The temperature in the conditioned space is maintained by the several zone thermostats T-1, which positions the automatic face dampers L and M.

When the outdoor temperature falls below the setting of thermostat T-11, all valves and controls change to their heating positions. The double-pole double-throw switch S-1 operates the 10 hp compressor through head pressure switch S-2; the immersion thermostat T-14, located in the condenser discharge, controls the 15 hp compressor through pressurestat P-4. Thermostat T-13, which controls the temperature in the plenum B by positioning water valve V-1, is readjusted by T-9 to a higher temperature setting as the outdoor air temperature falls. Pneumatic safety control thermostat T-15, located in the chiller discharge, and electrical immersion thermostats T_S on the inlet and outlet of both coolers, stop the compressors if the water temperature falls below their setting. In case the compressors cannot maintain the desired temperature in plenum B, pneumatic electric switch P-1 will close the circuit to the 15 kw heater.

In order to provide the simplest control to automatically lower the night temperature during the heating cycle, an electric clock transfers the control from thermostats T-1 and T-13 to return duct thermostat T-8.

When the outdoor temperature rises above the setting of thermostat T-11, all valves and controls are changed to their cooling position. During this cycle switch S-1 operates the 10 hp compressor from the suction pressure switch S-3 and the immersion thermostat T-15 controls the operation of the 15 hp

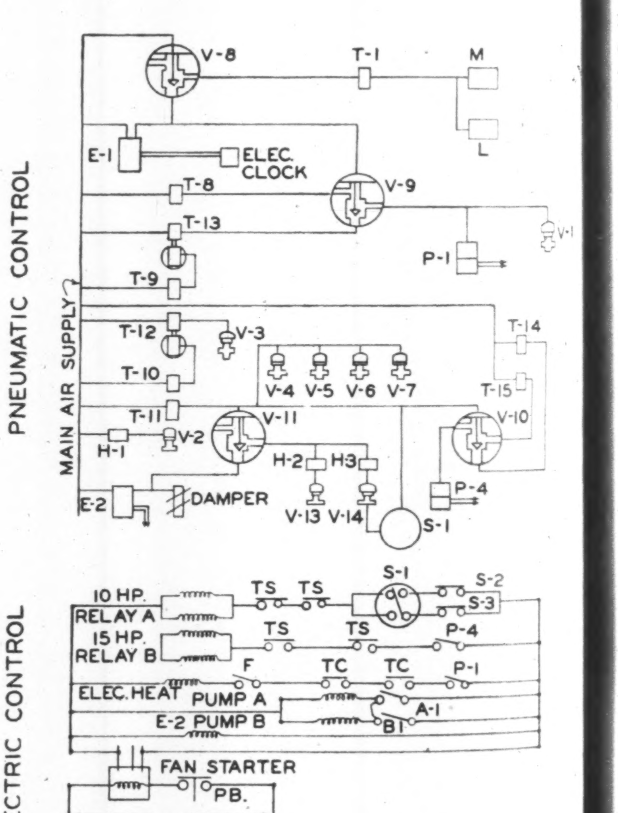

PNEUMATIC CONTROL
MAIN AIR SUPPLY
V-8
T-1
M
L
E-1
ELEC. CLOCK
T-8
V-9
T-13
T-9
P-1
V-1
T-12
V-3
T-10
V-4
V-5
V-6
V-7
T-14
T-15
T-11
H-1
V-2
V-11
V-10
H-2
H3
E-2
DAMPER
V-13
V-14
P-4
S-1
ELECTRIC CONTROL
10 HP. RELAY A
15 HP. RELAY B
TS
S-2
S-3
P-4
F
TC
P-1
ELEC. HEAT
PUMP A
A-1
E-2 PUMP B
B1
FAN STARTER
PB.
208 VOLTS

Fig. 14 — Electrical and pneumatic control diagram, Coshocton system

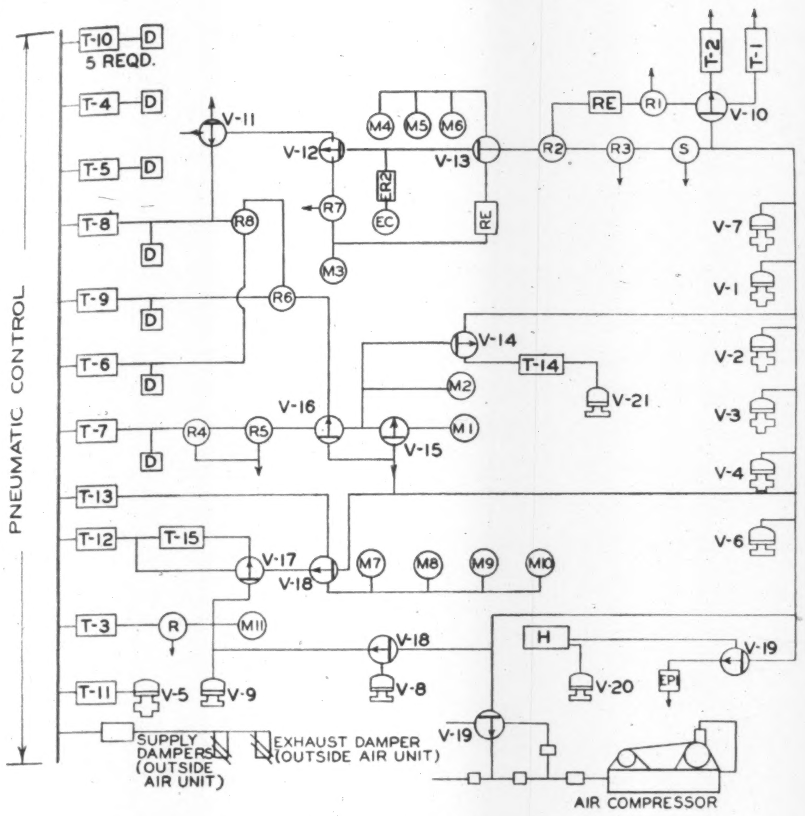

PNEUMATIC CONTROL
T-10
D
5 REQD.
T-4
T-5
T-8
T-9
T-6
T-7
T-13
T-12
T-15
T-3
T-11
V-11
V-12
V-13
V-10
V-14
V-16
V-15
V-17
V-18
V-19
V-21
V-20
V-7
V-1
V-2
V-3
V-4
V-6
V-5
V-9
V-8
T-2
T-1
T-14
RE
R1
R2
R3
R4
R5
R6
R7
R8
R
S
H
EP1
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
ER2
EC
SUPPLY DAMPERS (OUTSIDE AIR UNIT)
EXHAUST DAMPER (OUTSIDE AIR UNIT)
AIR COMPRESSOR

Fig. 15—Pneumatic control for Portsmouth system

compressor. Return air thermostat T-12, which controls the air in the plenum A by positioning water valve V-3, is readjusted to a lower setting as the outdoor temperature rises. Auditorium humidistat H-1 controls valve V-2 on the auditorium dehumidifying coil G, opening the valve on a rise in humidity.

B—Portsmouth System

The pneumatic and electric control diagram for the operation of this system is shown by Figs. 15 and 16. The temperature in the conditioned space is maintained by zone thermostats T-4 to T-9, which modulate their respective face and by-pass dampers.

During both cycles of operation the compressors are electrically interlocked with the outside air fan so that one-half of the air flow is circulated when using one compressor and the full quantity when both compressors are operating. Pressurestats are installed on both sides of the cooler as a safeguard against freezing.

When the outdoor-recirculated air falls below the setting of the return airstat T-1, all controls and valves change to their heating position. Thermostats T-6, T-8 and T-9, located in the zones which may require cooling when the other zones require heating, can operate pump "C" providing the face dampers on the bypass coil are fully open, in which case T-11 in the pump "C" discharge will control 3-way valve V-5 with modulation action to produce the desired liquid temperature going to bypass coil. When the outdoor air falls below 20 F, thermostat T-3 will stop the outside air fan, causing the intake and exhaust dampers to close and the city water supply valve V-9 to open, spraying water over the outside coil. The four steps of compressor capacity during this cycle are under control of thermostat T-12, located in the liquid outlet of the conditioner coil.

During the night cycle the electric clock E, at a predetermined time, energizes magnetic pilot valve ER-2, thus transferring control of the heating cycle to thermostat T-8. The equipment will then operate intermittently in response to thermostat T-8.

When the outdoor-recirculated air rises above the setting of return airstat T-2, the system is changed to the cooling cycle. The four steps of compressor capacity modulation are controlled by thermostat T-13, located in the liquid discharge from the conditioner coil. During this cycle the electric clock E, by energizing magnetic pilot valve ER-2, stops the fans and com-

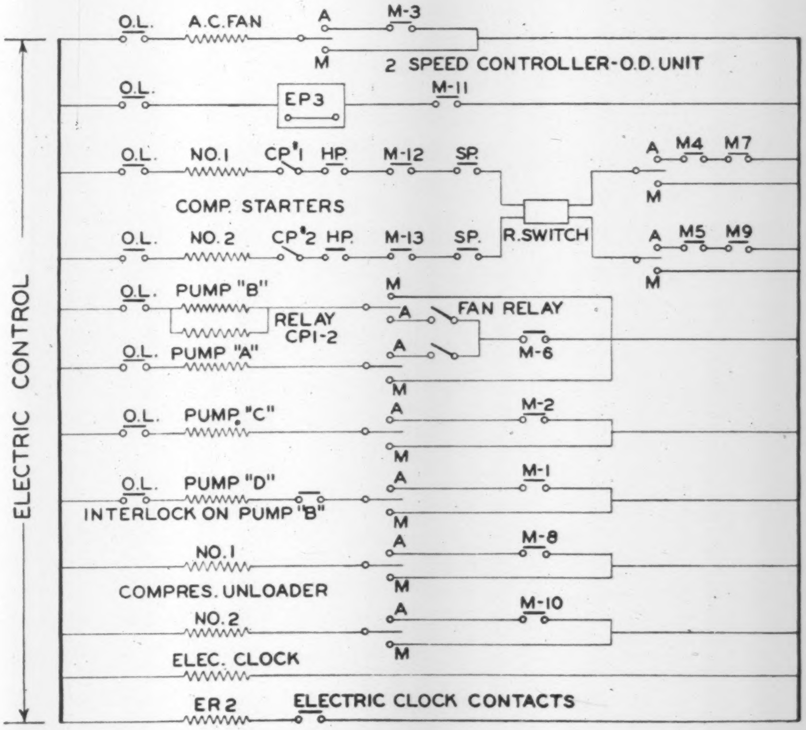

ELECTRIC CONTROL
O.L.
A.C. FAN
A
M
M-3
2 SPEED CONTROLLER-O.D. UNIT
EP3
M-11
NO.1
CP#1
HP.
M-12
SP.
COMP. STARTERS
NO.2
CP#2
M-13
R. SWITCH
M4
M7
M5
M9
PUMP "B"
RELAY CP1-2
FAN RELAY
PUMP "A"
M-6
PUMP "C"
M-2
PUMP "D"
INTERLOCK ON PUMP "B"
M-1
NO.1
COMPRES. UNLOADER
M-8
NO.2
M-10
ELEC. CLOCK
ER 2
ELECTRIC CLOCK CONTACTS

Fig. 16—Electric control for Portsmouth system

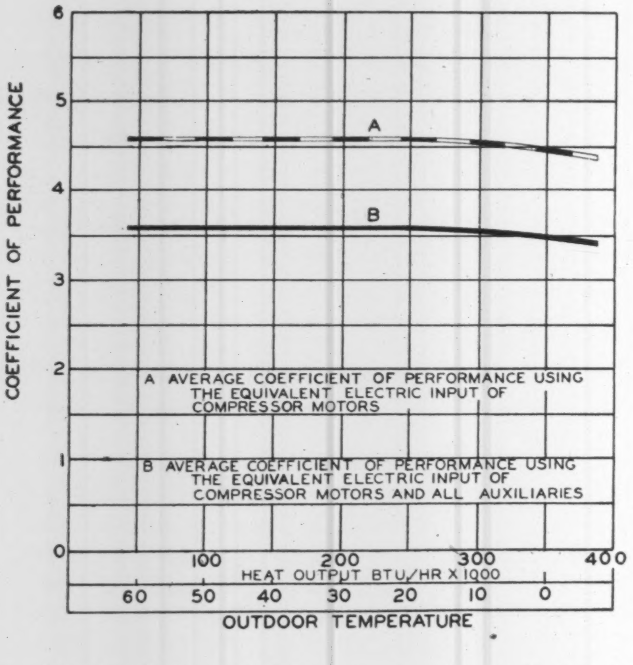


Fig. 17—Average coefficient of performance, Coshocton system

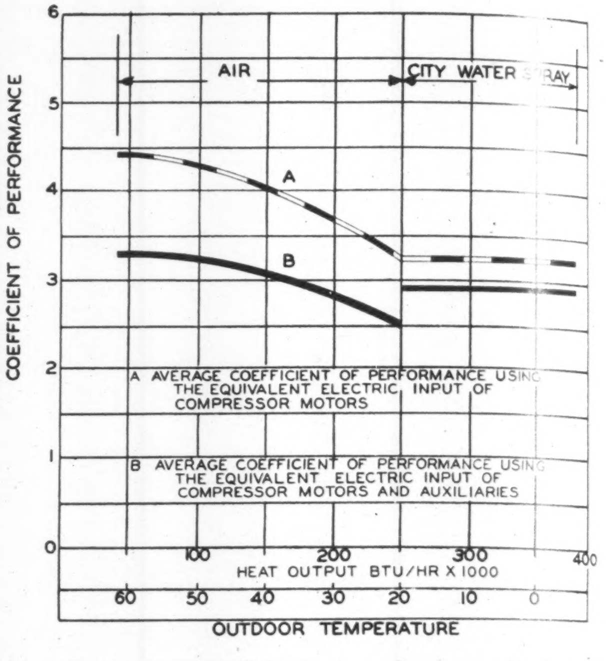


Fig. 18—Average coefficient of performance, Portsmouth system

pressors through M4, M5 and M6 during the night period.

Performance

Table 3 shows a sample of the test data obtained to check the coefficient of performance for the Coshocton system. This data indicates the probable temperatures of the circulating liquids in the two circuits and the resulting heat output of the system for three different operating cycles at substantially the same outdoor temperature. However, the data as it stands can be misleading since it does not represent a true balance for any particular operating condition of the system. It was necessary to make a series of such tests over the past two winters at various outdoor temperatures because it is practically impossible to obtain a period when the heating requirements of the building will exactly balance the output of the system. This data was then plotted and used together with manufacturer's data to obtain the curves shown in Fig. 17, giving weight to the fact that in many cases the compressor head pressure and the liquid circulating temperature were either higher or lower than would be experienced under balanced operating conditions. The solid lines indicate the average coefficient of performance using the electric input to the compressor motors and all the auxiliary equipment, while the broken line includes the compressor motor input only. A comparison of curves A and B shows that the auxiliary equipment reduces the coefficient of performance approximately 22 per cent.

The slight drop in the coefficient of performance for the Coshocton system, under maximum output, is partly due to the rising of the heating coil inlet water temperature as the outdoor temperature falls and partly because the 10 and 15 hp condensers are the same size. This causes the 15 hp compressor to operate at a relatively high head pressure when both units are under full load, thus resulting in an increase in its power input and a corresponding reduction in the coefficient of performance.

Table 4 shows a sample of the test data obtained over the past two winters to check the coefficient of performance for the Portsmouth system. The data were tabulated and plotted to give curves shown in Fig. 18. The same comments made on the Coshocton tests apply similarly to the Portsmouth tests. It will be noted that the coefficient of performance drops rather uniformly as the outdoor temperature falls until 20 F is reached, at which point water is introduced as the source of heat. The falling off of the coefficient is caused mainly by the decrease in suction pressure resulting from the frosting of the outdoor coil and the temperature reduction of the heat source. Both of these phenomena cause the head pressure-suction pressure differential to increase and the Btu per kilowatt to decrease.

Defrosting of the outdoor coil at Portsmouth is accomplished by reversing the cycle of operation and/or spraying with water, but neither method is too satisfactory. Other defrosting methods are being investigated, but to date this remains a problem to be solved. However, the defrosting problem which has been experienced at Portsmouth cannot be considered a serious objection, since the difficulty occurs at rather infrequent intervals. On the whole, the system is operating quite satisfactorily without an undue amount of maintenance.

Conclusions

The results of operation observation of, and tests on, the heat pump installations at Coshocton and Portsmouth lead to the following conclusions:

1. **The heating system using water as the heat source operates satisfactorily throughout the range of outdoor temperatures encountered and the system employing air as the source of heat is satisfactory up to outdoor air temperatures of approximately 20 F.**

2. **The idea of using water as an auxiliary heat source, as carried out at Portsmouth, when outdoor tem-**

Table 4—Actual Performance Data for Portsmouth System

	Tests			
	No. 1	No. 2	No. 3	No. 4
Supply Air to Conditioned Space				
Cubic feet per minute	18,000	18,000	18,000	18,000
Temperature, degrees Fahrenheit	77.1	85.1	78.9	87.2
Outside Air				
Cubic feet per minute	2,000	2,000	2,000	2,000
Temperature, degrees Fahrenheit	32	32	32	32
Conditioner Heating Coil (for location see Figs. 8 and 12)				
Entering Liquid Temperature, degrees Fahrenheit	85	97.2	87.5	100
Leaving Liquid Temperature, degrees Fahrenheit	81.0	90	83	92
Gallons per minute	95	95	95	95
Liquid Cooler (for location see Figs. 10 and 12)				
Entering Liquid Temperature, degrees Fahrenheit	21.2	19	28.5	26
Leaving Liquid Temperature, degrees Fahrenheit	18.2	13.8	25	20
Gallons per minute	95	95	95	95
Electric Consumption				
Compressors, kilowatts	16.6	32.4	17.8	35.1
Auxiliaries, kilowatts	9.2	11.1	4.8	4.8
Total kilowatts[a]	25.8	43.5	22.6	39.9
Capacity				
Refrigeration, Btu/hour	140,000	250,000	168,000	284,000
Heat Output, Btu/hour	187,200	342,000	218,500	383,500
Coefficient of Performance				
Using Kilowatt Input to Compressor	3.3	3.1	3.6	3.2
Using Total Kilowatt Input[b]	2.2	2.4	3.0	2.9

Test No.
1—1-25 Hp Compressor: 135 psi head pressure—11 psi suction
2—2-25 Hp Compressor: 160 psi head pressure—10 psi suction
3—1-25 Hp Compressor using water spray—140 psi head pressure—16 psi suction
4—2-25 Hp Compressor using water spray—170 psi head pressure—12 psi suction

[a] Kw to conditioner supply fan not included.
[b] 60 per cent of kw input to circulating pumps included as useful work.

peratures are below 20 F, has not proven fully satisfactory mainly because the temperature of water available was around 38 F. This not only required a great quantity of water to obtain the necessary heat but also caused the compressor to operate at a relatively low suction pressure.

3. Operation of the air system at temperatures below 20 F has not proven satisfactory. On several occasions when this was attempted at Portsmouth, difficulty resulted because the frosting of the outdoor coil seriously affected the capacity.

4. Improvements in means and methods of defrosting the outdoor coil are a much needed development for successful heat pump installations using air as the heat source where temperatures below 20 F are encountered.

5. Experience both at Coshocton and Portsmouth indicates not only the desirability and need, but also the possibility of simplifying controls. Thus, at Coshocton there was shown on the whole little need for outdoor compensators to change the setting of the controlling thermostats. At Portsmouth justification has not been shown for the multiplicity of thermostats installed to obtain refinements of operation.

6. The indirect systems at Coshocton and Portsmouth have given less operation and maintenance trouble than the direct systems which have been installed elsewhere on properties of American Gas and Electric Co. It is believed that at least part of this improvement is due to having a fixed refrigerant circuit, thus eliminating probable trouble from reversing valves in the refrigerant circuit and erratic oil return. But most of the improvement is believed due to the advancements which have been made in the manufacture and installation technique of the refrigeration equipment. Further study and additional experience is necessary to determine which type of design is more economical and what improvements can be made in each system to achieve better year-round performance.

7. Average coefficients of performance of 3.0 on the air system and 3.6 on the water system are impressive results. Both are, however, susceptible to improvement as advancements are made in design and performance of the refrigeration compressor, heat transfer surfaces and other equipment making up the system which will result in increased operating suction pressures and in decreased head pressures. Also, considerable possibilities exist for reducing and in many cases completely eliminating the auxiliaries which in the case of Portsmouth and Coshocton systems reduce the average coefficient of performance approximately 22 per cent.

8. The heat pump, properly engineered and installed from an application and design standpoint, is even now a wholly practical device to furnish year-round all-electric air conditioning service. Its further development should make it even more so.

Acknowledgment

The authors wish to acknowledge the cooperation and assistance of the engineers of the General Electric Co. and the Westinghouse Electric and Manufacturing Co., and William H. Torges, R. H. Anders and E. L. Vogt of The Ohio Power Co. for their help in making the observations and tests and following the operation of the systems.

1944-45 FUEL OIL RATIONING PROGRAM

The OPA rationing program for 1944-45 is based on the assumption that there will be no more heating oils available than this year and that there may be less kerosene. Should larger supplies later prove to be available, adjustment can be made through increasing the unit value of the coupons.

It is anticipated that the following provisions will be included in the new plan:

Heating rations will generally be the same as those issued for 1943-44 except that boards which have not already done so will review space heater rations and apply 550 sq ft of area ceiling as the maximum.

Hot water for private dwellings will be issued on same basis. Any changes in number of occupants or months required will be adjusted on basis of facts appearing on reapplication form.

Rations for 1101 consumers will be reissued on present basis.

The heating year will be from September 1, 1944, to August 31, 1945.

The heating year will again be divided into five heating periods. In the Midwest and South, Periods 2 and 3 and also 4 and 5 will again be combined. It is hoped that the supply situation will warrant combining Periods 4 and 5 in the East. Increasing military requirements and the unpredictability of the supply picture make it necessary to retain the five period set-up.

The present ten zones into which the limitation area is divided will be continued.

Validity Dates

Definite value coupons and Period 1 coupons will be valid on July 1, 1944, and all coupons will remain valid until end of heating year, August 31, 1945. Degree day distribution of periods will be readjusted to facilitate consumer budgeting and the scheduling of deliveries. This will be accomplished by lengthening Periods 1 and 5, and shortening the other three periods, which automatically advances the opening date of Period 5.

Additional Rations for Summer Hot Water

Boards have already been instructed on the procedure for handling applications for additional oil to take care of undue and immediate hardship arising from the lack of oil for summer hot water.

The amount of oil to be granted by the board for hot water shall not exceed the gallonage indicated in Table 3 of the Local Board Fuel Oil Calculation Tables issued in October 1942, for the number of occupants of the dwelling and the number of months for which it is to be used up to August 31, 1945.

John Ball Park

Grand Rapids Greets ASHVE

At the Semi-Annual Meeting 1944 emphasis will be on the subject of Fuel Conservation, particularly economic utilization for all heating services and special attention will be directed toward air treatment and the removal of health hazards in war production industries. Cooperative research papers on heat loss studies and attic ventilation are also scheduled for presentation.

Important revision of the Society's By-Laws will be discussed at the opening session, and many of the Research Technical Advisory Committees and other special committees will hold meetings.

Members of the Western Michigan Chapter Committee on Arrangements have planned a fine program in which members and ladies can participate.

The meeting will open on June 19 and members should make their hotel and railroad reservations as early as possible.

The City of Grand Rapids has received national acclaim as The Furniture Capital of America, but it also has many diversified industries and produces a great variety of materials within the city limits. There are many scenic spots, such as John Ball Park, the winding paths through Hodenpyl Woods, Reed's Lake, many golf courses, and Lookout Park with its sweeping view of the valley and the Grand River. Visitors to Grand Rapids will notice that all its streets are track free, and a view of Monroe Avenue looking toward the meeting headquarters, the Pantlind Hotel, shows the width of the well paved streets which are common in the city. Across the street from the headquarters hotel is the Civic Auditorium, which is one of the most modern and commodious public halls in the country, with its great hall seating 5700, and the black and silver room seating 1000 people.

There will be an opportunity to visit the Furniture Museum, which houses some priceless antiques and gives a fascinating picture of furniture progress for a period of over 100 years. These and many other interesting places may be seen by the visitor to Grand Rapids.

The officers and members of the Western Michigan Chapter offer their hospitality and want to welcome you to Grand Rapids, June 19-20.

The Furniture Museum

H. D. Bratt

T. D. Stafford

C. H. Pesterfield

L. G. Miller

W. W. Bradfield

O. D. Marshall

Committee on Arrangements

T. D. Stafford, *General Chairman*
W. W. Bradfield, *Honorary Chairman*
Vice-Chairman
H. D. Bratt
C. H. Pesterfield

Reception: **L. G. Miller, *Chairman*; Messrs. and Mmes. Arthur Boot, W. W. Bradfield, H. D. Bratt, Axel Marin, O. D. Marshall, C. H. Pesterfield, T. D. Stafford, F. C. Warren, K. L. Ziesse.**

Banquet: **F. C. Warren, *Chairman*; S. H. Downs, F. T. Goodwin, L. G. Miller, S. S. Sanford, A. H. Snook, L. A. Tilford, P. O. Wierenga.**

Finance: **K. L. Ziesse, *Chairman*; S. J. Dempsey, Frank Harbin, Jr., H. R. Limbacher, H. F. Reid.**

Golf: **W. G. Schlichting, *Chairman*; R. E. Distel, V. H. Hill, H. J. Metzger, C. A. Simonds, H. J. Young, K. L. Ziesse.**

Mrs. O. D. Marshall

W. G. Schlichting

Inspection Trips: **Arthur Boot, *Chairman*; H. D. Bratt, Thomas Chester, W. H. Old, K. E. Robinson, J. J. Wieland, H. W. Wolters.**

Ladies: **Mrs. O. D. Marshall, *Chairman*; Mmes. W. G. Boales, W. W. Bradfield, H. D. Bratt, Harry Christenson, S. H. Downs, V. H. Hill, L. G. Miller, C. H. Pesterfield, W. G. Schlichting, T. D. Stafford, F. C. Warren, K. L. Ziesse.**

Publicity: **V. H. Hill, *Chairman*; H. A. Brinker, A. R. Frantz, A. E. Knibb, R. W. Wilson.**

Special Events: **O. D. Marshall, *Chairman*; W. G. Boales, L. A. Caleaterra, Harry Christenson, D. E. DeVries, C. R. McConner, J. W. Miller.**

Arthur Boot

V. H. Hill

F. C. Warren

Karl Ziesse

Program
ASHVE
Semi-Annual
Meeting

Pantlind Hotel
Grand Rapids, Mich.
June 19-20, 1944

← **Looking toward Meeting Headquarters**

Sunday, June 18

10:00 a.m. Guide Publication Committee Meeting, J. F. Collins, Jr., *Chairman*
Finance Committee Meeting, B. M. Woods, *Chairman*
1:30 p.m. Council Meeting
2:00 p.m. Research Technical Advisory Committee Meetings
9:30 p.m. Reception and Buffet

Monday Morning

8:30 a.m. REGISTRATION (*Mezzanine*)
9:30 a.m. BUSINESS SESSION (*Ballroom*)
Greetings—H. D. Bratt, President, Western Michigan Chapter
Response by Pres. S. H. Downs
Amendments to By-Laws
Selecting Winter Design Temperatures, by Paul D. Close
Periodic Heat Flow—Homogeneous Walls or Roofs, by C. O. Mackey and L. T. Wright, Jr.
A Method of Heating a Corrugated-Iron Coal Preparation Plant, by E. K. Campbell
12:15 p.m. Get-Together Luncheon (*Grille*)
Speakers—Hon. George W. Welsh, Mayor of Grand Rapids
Dr. M. M. McGorrill, What Makes an Engineer Tick?

Monday Afternoon

1:30 p.m. Ladies leave Pantlind Hotel for Grand Rapids Furniture Museum
2:00 p.m. Education—The Engineer's Major Job in Heating and Fuel Conservation, by K. C. Richmond
PANEL DISCUSSION—Fuel Conservation
3:15 p.m. Baker Furniture Exhibition
4:00 p.m. Research Technical Advisory Committee Meetings
4:00 p.m. Inspection Trips
5:30 p.m. Chapter Delegates' Conference
7:00 p.m. Dutch Treat Party (*Grille*)

Tuesday Morning

8:30 a.m. REGISTRATION (*Mezzanine*)
9:30 a.m. TECHNICAL SESSION (*Ballroom*)
The Engineering Control of Some Solvent Hazards in War Industries, by S. C. Rothman
Industrial Exhaust Ventilation in Industrial Hygiene, by A. D. Brandt
The Use of Glycol Vapors for Air Sterilization and the Control of Air Borne Infection, by B. H. Jennings, Edward Bigg and F. C. W. Olson
Air Disinfection in Ventilation, by W. F. Wells
10:30 a.m. Ladies Leave Pantlind Hotel for Brunch and Bridge at Cascade Country Club
12:00 p.m. Nominating Committee Meeting

Tuesday Afternoon

2:00 p.m. TECHNICAL SESSION (*Ballroom*)
Some Effects of Attic Fan Operation on Comfort, by W. A. Hinton and W. G. Wanamaker
Train Piston Action Ventilation and Atmospheric Conditions in Chicago Subways, by W. E. Rasmus and Edison Brock
Description and Performance of Two Heat Pump Air Conditioning Systems, by Philip Sporn and E. R. Ambrose
3:00 p.m. Rug Demonstration
4:00 p.m. Committee on Research
7:00 p.m. Semi-Annual Dinner (*Ballroom*)
Toastmaster—Roger Allen
Tribute to Members in the Armed Forces
Address—Geography in the News, by Prof. Edward C. Prophet
Presentation of the Past President's Memory Book to M. F. Blankin

Wednesday, June 21

a.m. Fishing trip

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members be empowered to form a General Committee with such subcommittees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Atlanta	April 17	Present Trends in Fighter Aircraft	Alan Pope, Guggenheim School of Aeronautics, Georgia Tech	Classification of Membership in Atlanta Chapter discussed	22	0.47
Cincinnati	April 12	Heating and Air Conditioning in the Latin-American Countries	A. J. Offner, 2nd Vice-Pres., ASHVE, New York, N. Y.	Amos Hard reported for the Nominating Committee	23	0.47
Delta	April 11	Astronomy and Its Relation to Comfort	C. M. Rogers, New Orleans Public Service, Inc.	Special entertainment by Leon Jacobs, local business leader and magician	19	0.39
Golden Gate	April 13	The Flow of Gas and Air in Various Systems	S. H. Downs, Pres. ASHVE, Kalamazoo, Mich.	R. A. Folsom reported as chapter representative to California Assn. of Architects and *ASRE* San Francisco Section Meetings	39	0.50
Illinois	April 10	Advantages of Construction and Maintenance by Use of Liquid Heat Carrier	Read by S. I. Rottmayer in absence of S. R. Lewis, Cons. Engr.	C. E. Price reported on War Production and Related Problems Conference	80	0.54
		Heating by Radiant Energy	I. E. Brooke, Cons. Engr.	K. C. Porter gave the Treasurer's report.		
		High Pressure Air Distribution in Refrigeration	W. S. Bodinus, Carrier Corp.	J. S. Kearney reported on membership		
Kansas City	April 24	Radiant Heating for Postwar Construction	C. A. Hawk, A. M. Byers Co., Pittsburgh, Pa.	M. M. Rivard reported for Nominating Committee	67	1.19
Manitoba	April 5	Flow of Gas and Air in Various Systems	S. H. Downs, Pres., ASHVE, Kalamazoo, Mich.	Nominating Committee	24	0.75
Massachusetts	April 18	Practical Experiences with Hot Water Heating.			48	0.80
Michigan	April 17	Past Presidents' Night	The 13 past presidents were present and introduced	Motion picture, "On the Air—A Story of Broadcasting"	120	1.12
Montreal	April 17	City Owned Land and Housing	P. E. Nobbs	A. M. Peart commented on forthcoming membership drive	28	0.46
Nebraska	April 12	Present Day Trend in Advertising of Post-War Building Materials	G. E. Merwin	D. D. Williams reported on membership and attendance	16	0.87
New York	April 17	Heating and Ventilating of Ships	J. W. Markert, U. S. Maritime Commission	Annual Report of Treasurer	330	1.80
				Report of Tellers for 1944-45 Slate		
		Power Plants and Piping Installations on Ships	R. A. Frazier, G. G. Sharp's office	Report of Auditing Committee		

CHAPTER	MEETING DATE	SUBJECT	SPEAKERS	OTHER FEATURES	ATTENDANCE	ATTENDANCE RATIO*
North Carolina	April 28	Annual Meeting Postwar Plans for Engineering School at N. C. State College	R. B. Rice, North Carolina State College	Arvin Page reported as Chapter Delegate to New York Meeting	40	.58
		Air Conditioning in the Textile Mill	Arvin Page, Ch. Engr., The Bahnson Co.	Election of Officers		
North Texas	April 17	Utilization of Natural Gas as a Fuel in Heating Boilers	L. F. Reagan, Vice-Pres., Webster Engrg. Co., Tulsa, Okla.	John Ray reported on membership	50	0.65
Northern Ohio	April 10	Air Conditioning for Penicillin	L. T. Avery, Pres. Avery Engrg. Co.	J. F. Platz reported on membership	58	0.72
Ontario	May 1	Annual Meeting "Old Timers' Night"	R. H. Lock supervised entertainment.	H. D. Henion presented W. C. Kelly with past president's certificate. Mr. Kelly also received a duffel bag and a Scroll from Ontario Chapter before leaving for St. Louis to take up new duties.	84	0.59
		Election of Officers				
Pacific Northwest	April 10	The Flow of Gas and Air in Various Systems	S. H. Downs, Pres., ASHVE, Kalamazoo, Mich.	Prof. E. O. Eastwood introduced President Downs	49	0.66
Philadelphia	April 13	Pentagon Building, Washington, D. C.	C. S. Leopold, Consulting Engr.	Election of Officers	151	1.26
Pittsburgh	April 10	Research Activities	Cyril Tasker, Dir. of Research, ASHVE	J. F. Collins, Jr., reported for Nominating Committee	27	0.41
		What the Salvation Army is Doing in This War	Capt. John Train	Guests introduced: C. S. Leopold, Philadelphia; G. H. Tuttle, Detroit; A. V. Hutchinson and Carl Flink, New York		
		Fuel Conservation Program	H. F. Hebley, Dir. of Research, Pittsburgh Coal Co., and Regional Coordinator for U. S. Fuel Conservation Program			
South Texas	May 2	Joint Meeting with Houston Engineers Club		D. S. Cooper reported on Building Code Committee progress	17	0.34
		Plant Protection at Bethlehem Steel Plants (film)		Walt Disney films showing operation, use and maintenance of C-1 auto pilot and electronics		
	March 30	Postwar Development (sound film)		Membership drive discussed	34	0.68
				Report of Houston Building Code Committee by D. S. Cooper and Bert Fisher		
Southern California	April 17	The Flow of Gases and Air in Ducts	S. H. Downs, Pres., ASHVE, Kalamazoo, Mich.	ASRE members were guests	67	0.89

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Washington, D. C.	April 12	Heating and Air Conditioning in South America	A. J. Offner, 2nd Vice-President of ASHVE, New York, N. Y.	W. C. Jones gave report of Nominating Committee An official Marine Corps film of Invasion of Marshall Islands was shown	70	0.41
Western New York	April 17	Air Conditioning in Latin America Specialized Medicine	A. J. Offner, 2nd Vice-Pres. of ASHVE, New York, N. Y. Dr. John Naples, Pres. Erie County Medical Assn.	M. C. Beman reported for Nominating Committee	61	0.82
Wisconsin	April 17	Boiler Controls Dealing with Automatic Fired Boilers	M. W. Crew, Perfex Co., Milwaukee	Report of Nominating Committee submitted C. E. Price, Pres. of Illinois Chapter, was introduced	42	0.7

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters and may be helpful in deciding on subjects for other chapter meetings.

DR. ROSE OF MELLON INSTITUTE ELECTED TO NEW POST

Dr. Harold J. Rose, Mellon Institute, Pittsburgh, has been elected vice-president and director of research in charge of the expanded investigational and developmental program of the bituminous coal industry, as announced recently by the Bituminous Coal Research, Inc. Dr. Rose, a member of the ASHVE, having served on many of its research committees, has had extensive experience in the technical and administrative phases of coal research. He is the author of many scientific papers on bituminous coal, coke, gas, chemical by-products, and anthracite, and has been granted a number of patents.

He is also a member of the National Fuel Efficiency Council, and of the OPA Stove Industry Advisory Council, and has been chairman of many national committees of engineering and allied chemical societies, being affiliated with the *American Chemical Society, American Gas Association, American Institute of Mining and Metallurgical Engineers, American Society for Testing Materials, American Institute of Chemical Engineers,* and the *Eastern States Blast Furnace and Coke Oven Association.*

Dr. Rose, a native of South Dakota, was educated at Yankton College, the University of Chicago, and Carnegie Institute of Technology. He holds degrees of B.A. and Sc.D., and in 1928 received the Grasselli Medal of the *Society of Chemical Industry.*

NEW APPOINTMENTS

George Gouler has been appointed sales manager of the Air Conditioning Controls Division, Minneapolis-Honeywell Regulator Co., with headquarters at the home office of the company in Minneapolis, Minn., according to the announcement of Vice-President C. B. Sweatt.

L. Gale Huggins has been appointed Manager of Air Conditioning for the Westinghouse Electric Elevator Co., Jersey City, N. J., according to the announcement of Ross Rathbun, Manager of the Division. Mr. Huggins will be general assistant to the manager and his duties will include administration, engineering and application matters.

PERCY BRYANT DIES IN WESTFIELD, N. J.

Percy J. Bryant, a member of the Society since 1915 and for the last 15 years chief engineer of the Prudential Life Insurance Company Building, Newark, N. J., died at his home, 754 Belvidere Ave., Westfield, N. J., on April 27, 1944.

Mr. Bryant, born in 1884, was graduated from Purdue University in 1908. He spent eight years in government and state institutional heating work in both consulting and operating capacities, specializing in power, heating and ventilating, refrigeration, water supply, electricity, and sanitation.

He was chief engineer at the United States Military Academy at West Point, N. Y., for 15 years, and served three years with the National Guard.

The many friends and business associates of Mr. Bryant will feel his loss keenly.

The Officers and Council of the Society wish to convey their deepest sympathy to his widow, Mrs. Lola Whitsel Bryant, and to his sons, William W. and P. John Bryant, who survive.

MICHIGAN CHAPTER ANNOUNCES DEATH OF W. E. STARK

Word has just been received of the untimely death of W. Elliott Stark, Detroit, Mich., on May 10, 1944, at the age of 52.

Mr. Stark, well known in the air conditioning and gas heating field, was born June 18, 1892, at Decatur, Ill., where he received his early training. He was graduated from Purdue University with B.S. and M.E. degrees. His early technical and business experience included design, manufacturing, sales, and installation of heating, ventilating and air conditioning equipment work, and also engineering teaching. He specialized in industrial air conditioning, particularly gas burning industrial dehumidifying equipment.

In 1914 he was employed by B. F. Sturtevant Co. as assistant engineer, and after a year's experience he became instructor at Michigan Agricultural College. Following this assignment he joined the staff of Case School of Applied Science, Cleveland, Ohio, as instructor, which was interrupted in 1917 when he became Captain in the Corps of Engineers in the U. S. Army, and served overseas in combat duty. His military experience covered a period of 20 years as Regular Army, Reserve and National Guard Engineer Officer. He resigned from the National Guard in 1937 as Major.

In 1919 he returned to Case School of Applied Science as Assistant Professor, remaining in that capacity until 1924, when he became Research Engineer for the Bryant Heater and Mfg. Co., Cleveland. He progressed to the position of Regional Manager, which he held until October 1943, when he joined the Engineering Department of the Timken Silent Automatic Division, Detroit, Mich.

Major Stark joined the Society in 1926, and immediately became an active member. In the Cleveland Chapter he served on the Board of Governors in 1928 and 1932, and was President of the Chapter in 1931-32. He served as Chairman of the Committee on Gas Heating Equipment from 1932-35, and was a member of the Committee on Heat Transfer of Finned Tubes with Forced Air Circulation for three years.

He was a member of the Society's Council for a period of six years, 1932 to 1937, inclusive, and during those years served at various times as a member of the Finance and Membership Committees, and as Chairman of the Meetings Committee for one year.

In 1935 he was appointed a member of the Committee on the F. Paul Anderson Award. He also was a member of the Constitution and By-Laws Committee in 1936, 1938, 1940, and 1941, and was Chairman of the Technical Advisory Committee on Weather Design Conditions in 1937.

Major Stark was greatly respected by his fellow engineers, having won himself a reputation for integrity and ability. The Society, which he served so faithfully, has lost an outstanding and valuable member. Major Stark made many contributions to research and leaves an enduring monument in this field of engineering.

He was also a member of the *American Society of Mechanical Engineers*, serving on the *ASME* Boiler Code Committee, the *Society of the American Military Engineers*, and a member of the *American Gas Association*.

The Officers and Council of the Society wish to extend their deepest sympathy to Mrs. Stark in her bereavement.

W. G. R. BRAEMER DIES AT 74

After several months' illness, William G. R. Braemer, pioneer manufacturer of humidifiers and other air conditioning apparatus, passed away on March 20, 1944, at his home, 206 E. Park Ave., Haddonfield, N. J.

Mr. Braemer was born in Denmark on November 1, 1870, where he received his early education. He was graduated from the College of Technology, Denmark, in 1892 with a degree of M.E. His drafting and shop experience began in Denmark in 1885, when he was employed as a blacksmith's helper. In 1889 he passed the examination as a machinist and shortly after his graduation from college he came to the United States.

From November 1893 to May 1895 he was associated with B. F. Sturtevant Co., Chicago, as draftsman, leaving there in 1895 to become draftsman and chief heating and ventilating engineer for Buffalo Forge Co., Buffalo, N. Y. After 11 years with Buffalo Forge he joined the staff of Warren Webster and Co., where he organized a new air conditioning department. He supervised the design of Webster air washers, humidity control and cooling systems, and he remained with the company as chief engineer for a period of 10 years.

Following this long experience in the industry, he organized the Braemer Air Conditioning Corp., Philadelphia, Pa., which took over the air conditioning division of Warren Webster, and which later was absorbed by the Carrier Engineering Corp.

In 1919 he opened up his own consulting engineering office in the Stephen Girard Bldg., Philadelphia, specializing in air conditioning and drying. In 1922 he became chief engineer for the American Moistening Co., Boston, Mass., and at the same time held a position as consultant for Grinnell Co., Providence, R. I., in the Dryer Division.

In 1926 he returned to the Philadelphia area, where he became chief engineer for the Universal Humidifying Co., believed to be the first manufacturer of an electrically-driven home humidifier, designed by Mr. Braemer.

Four years later he became manager of the Philadelphia office of the Niagara Blower Co., and in 1933 he again opened up an engineering office, specializing in industrial plants, power plants, refrigerator plants, heating, ventilating, and air conditioning. Associate engineer with Mr. Braemer in this office was J. H. Smith, formerly superintendent of construction and chief engineer of the Ballinger Co., Philadelphia.

Mr. Braemer was a member of the Society for over 21 years, and during that time he played an active part in Society affairs, contributing frequently to its Transactions and Guide. He was also active in the Philadelphia Chapter and served on its Board of Governors for a number of years when it was known as the Eastern Pennsylvania Chapter. He also served on the Legislation Committee of the Chapter, and as a member of this committee did considerable work on the Code Governing Heating and Ventilation of School Buildings for the City of Baltimore.

The heating, ventilating and air conditioning field has lost one of its pioneers, and Mr. Braemer will be greatly missed by his many friends and associates in the profession.

The Officers and Council of the Society wish to extend their sincere and heartfelt sympathy to his widow, Mrs. Bertha L. Braemer, and to his family, who survive.

944 WARTIME FUEL PROGRAM

All fuel, including coal, oil, gas, d wood will be scarce next winter the prediction of the Solid Fuels dministration for War.

In addition to the continued arcity of other fuels, we are con- onted this coal year (April 1944- arch 1945) with the fact that ere will be a deficit of approxi- ately 38,000,000 tons of coal, un- ss it can be reduced by vigorous easures to save fuel. This means at in view of our war-depleted anpower and equipment in the ines, we can expect to produce me 38,000,000 tons of coal less an the 685,000,000 tons that ould be required for all needs un- r present wasteful coal consum- g practices.

This threatening deficit is due to e following factors: (1) The eed of additional coal by indus- ies for making arms, supplies and equipment for our military forces has substantially increased over last year; (2) the mines are having to give up thousands of their younger men for military service.

This threatening deficit can be reduced only by full *understanding* of the problem by the public, and by full cooperation by the public with measures being taken by the Solid Fuels Administration for stretching the available coal to meet our needs. These measures comprise: (1) Steps to keep mines in continuous full operation. Generally speaking, the mines cannot store coal, and whenever sufficient orders are lacking to make full operations possible, production is curtailed. Therefore, the public must store coal during the warm season, as fast as the mines can produce it and dealers can make deliveries. (2) *Steps to assure that each consumer will get his fair share of the available coal.* The Solid Fuels Administration will see that the dealers in each community get their fair share of the available coal, coke and other solid fuels. It has enlisted the services of the dealers for carrying out a voluntary wartime distribution program. (3) *Since all fuel will be short next winter, it will be necessary for every consumer to conserve* it to the limit of his ability, if the available supplies are to be stretched sufficiently to prevent widespread civilian distress and avoid prolonging the war for lack of heat and energy. Vigorous application by the public of practicable heat-saving measures will save an appreciable amount of all kinds of fuel, and particularly coal.

To protect themselves and help the Nation in time of war, all classes of fuel users must get ready now to conserve fuel next winter, and do everything possible to save fuel.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants r membership in the Society. All applications for membership are to be sent to the Secretary and the names of appli- ants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other pproved manner as ordered by the Council. When replies are received from references, the Candidate's application hall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and ssigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. uring the past month 115 applications for membership have been received and the names of these men and their sponsors re published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, e Council, urge the members to assume their share of responsibility of receiving these candidates into membership by dvising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which t is the duty of every member to promote.

Unless objection is made by some member by June 20, 1944, these candidates will be balloted upon by the Council. hose elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADAMS, **GEORGE F.**, Engr., Midwest Plumbing & Heating Co., Denver, Colo.	L. R. O'Rear O. G. Ward	G. D. Maves J. H. McCabe
ADAMS, OCTAVIUS C., Sales Engr., The Meyer Furnace Co., New York, N. Y.	F. L. Meyer J. S. Cunningham	Chester Bertolette, Jr. A. J. Offner
AKERLOW, R. W., Engr., Stearns Roger Manufacturing Co., Denver, Colo.	L. R. O'Rear D. J. McQuaid	*Charles Voight *Durgin Van Law
ALLEN, **FRANK C.**, Mech. Engr., U. S. Bureau of Reclamation, Denver, Colo.	D. J. McQuaid L. R. O'Rear	G. D. Maves F. L. Adams
ANDERSON, **EDWIN C.**, Owner, Edwin C. Anderson Co., Denver, Colo.	F. L. Adams J. E. McNevin	Homer Addams W. T. Jones
ANDERSON, **ROBERT B.**, Owner, Denver, Colo.	F. L. Adams G. D. **Maves**	J. H. McCabe H. H. Herman
APPLEGATE, **FRANCIS R.**, Plant Service Engr., Pratt & Whitney Aircraft Corp. of Missouri, Kansas City, Mo.	R. B. Mason F. C. Burns	L. T. Mart C. A. Davis
ASHTON, **JED L.**, Owner, Ashton Heating & Air Conditioning, Salt Lake City, Utah.	H. G. Richardson B. F. McLouth	*G. W. Williams *H. K. Beecher, Jr.
BALCH, **ROBERT M., JR.**, Sales Mgr., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.	Lyman Gross F. M. Thuney	C. E. Wiser William McNamara
BEACH, **ALBERT F., JR.**, Engr., U. S. Engineer Office, New York, N. Y.	M. C. Giannini Thomas Baker	L. J. Wachs H. J. Rose
BEISEL, **KARL E.**, Asso. Naval Arch., Ventilation Sect., Norfolk Navy Yard, Portsmouth, Va.	G. E. Williams E. B. Cary	*W. C. Stubbs C. M. Sterne
BERNZEN, **JOHN**, Treas., City Plumbing & Heating Co., Boulder, Colo.	L. R. O'Rear D. J. McQuaid	F. L. Adams J. J. Johnson
BIGELOW, **FOLGER H.**, Branch Mgr., Ilg Electric Ventilating Co., Memphis, Tenn.	J. D. Flinn W. E. Thorpe	W. A. Danielson J. J. Nolan
BOLES, **HARRY S.**, Mgr., Mid-State Frozen Egg Corp., Indianapolis, Ind.	W. F. Freije G. B. Supple	Allen Hayes S. E. Fenstermaker
BRADBURY, **GEORGE L.**, Co-Partner & Mgr., Bradbury Brothers Heating Co., Denver, Colo.	L. R. O'Rear D. J. McQuaid	F. L. Adams J. J. Johnson

Brady, George A., Chief, Fuel & Htg. Sect., Office Service Command Engineer, Ft. Douglas, Utah.	B. F. McLouth H. G. Richardson	*N. Truax *E. E. Tughy
Brickham, Ben A., Consulting Engr., Denver, Colo.	O. G. Ward D. J. McQuaid	L. R. O'Rear F. L. Adams
Brown, Edward A., Gas Htg. & Combus. Engr., D/B E. A. Brown Manufacturing Agency, Omaha, Neb.	D. D. Williams H. W. Stanton	D. E. McCulley B. G. Peterson
Brown, Norman, Owner, Norman Brown Co., San Francisco, Calif.	J. F. Kooistra T. B. Hunter	F. W. Kolb L. H. Cochran
Browne, Leland W., Exec. Vice-Pres., The Darby Corp., Kansas City, Mo.	O. E. Harbordt F. F. Dodds	R. B. Mason F. C. Burns
Burney, L. Byron, Chief Engrg. Draftsman, Norfolk Navy Yard, Portsmouth, Va.	G. E. Williams E. B. Cary	*W. C. Stubbs C. M. Sterne
Butler, Robert P., Partner, Kerr Machinery Co., Detroit, Mich.	R. H. Carpenter W. T. Jones	W. H. Old G. D. Winans
Calcaterra, Louis A., Mgr., Bennett Fuel Co., Grand Rapids, Mich.	T. D. Stafford H. D. Bratt	F. C. Warren W. W. Bradfield
Carter, Chester A., Asso. Combus. Engr., Hq. 7th Service Command, R & V Branch, Omaha, Neb.	D. D. Williams F. F. Dodds	D. E. McCulley W. A. Russell
Cavanagh, P. A., Mgr., Philadelphia Office, The Herman Nelson Corp., Philadelphia, Pa.	J. O. Kirkbride H. M. Parent	G. W. A. Kappel E. K. Wagner
Chesarek, Joseph H., Chief, Refrig. & Vent. Sect., Office of Service Command Engineer, Hq. 9th Service Command, Ft. Douglas, Utah.	B. F. McLouth H. G. Richardson	*E. E. Tughy *N. Truax
Clapperton, T. C., Vice-Pres., Michael Stuart Co., Ltd., Toronto, Ont., Canada.	S. M. Peterkin V. J. Jenkinson	A. J. Strain W. H. Evans
Cochrane, William, A. C. Engr., Federal Shipbuilding & Drydock Co., Newark, N. J.	E. C. Shepard J. H. Reilly	*J. G. Kearney *S. Weening
Conover, Donald D., Gas Repr., Philadelphia Electric Co., Chester, Pa.	H. H. Erickson M. F. Blankin	C. F. Dietz A. E. Kriebel
Cook, Clifford B., Partner, F. G. Cook & Sons, Kenmore, N. Y.	B. C. Candee J. J. Landers	M. C. Beman S. M. Quackenbush
Cook, Vernon D., Partner, F. G. Cook & Sons, Kenmore, N. Y.	M. C. Beman J. J. Landers	S. M. Quackenbush B. C. Candee
Cosgrove, James J., Wholesale Mgr., LaSalle Coke Co., Montreal, Que., Canada.	T. H. Worthington A. M. Peart	Leo Garneau F. A. Hamlet
Crew, Morris W., Dept. Mgr., Perfex Corp., Milwaukee, Wis.	J. R. Vernon J. A. Cutler	H. W. Schreiber A. S. Krenz
De Vries, Don E., Engr., Nash-Kelvinator Corp., Grand Rapids, Mich.	T. D. Stafford H. D. Bratt	F. C. Warren W. W. Bradfield
East, Roy H., Combustion Engr., Hq. 9th Service Command, Fort Douglas, Utah.	B. F. McLouth H. G. Richardson	*E. E. Tughy *N. Truax
Engelbach, A. A., Gen. Mech. Engr., National Capital Housing Authority, Washington, D. C.	H. K. Kugel H. K. King	R. S. Dill P. R. Achenbach
Erickson, Harry H., Sales Engr., Haynes-Blankin Corp., Philadelphia, Pa. *(Advancement)*	M. F. Blankin E. N. McDonnell	A. E. Kriebel C. F. Dietz
Ferguson, Clemon E., Mech. Engr., Post Engineer's Office, Fort Douglas, Utah.	B. F. McLouth H. G. Richardson	*E. E. Tughy *N. Truax
Fischer, Carl S., Secy.-Treas., Fischer Heating & Plumbing Co., Memphis, Tenn.	J. D. Flinn J. J. Nolan	W. A. Danielson W. E. Thorpe
Frantz, Adolph R., Service Mgr., Duo Therm Div., Motor Wheel Corp., Lansing, Mich.	J. W. Miller V. H. Hill	C. H. Pesterfield L. G. Miller
Froese, E. A., Branch Mgr., York Corp., Denver, Colo.	L. R. O'Rear O. G. Ward	G. D. Maves F. L. Adams
Gerrish, Grenville B., Asst. to Gen. Plant Mgr., Fitzgibbons Boiler Co., Inc., Oswego, N. Y. *(Advancement)*	Homer Addams James Holt	R. C. Malvin E. G. Carrier
Goodwin, Frank T., Repr., Forest City Foundries Co., Grand Rapids, Mich.	F. C. Warren M. B. Shea	H. M. Keyser R. C. Champlin
Gordon, Peter B., Treas. & Engr., Wolff & Munier, Inc., New York, N. Y. *(Advancement)*	H. B. Eells F. E. W. Beebe	Russell Donnelly W. M. Heebner
Gritton, Earl V., Mech. Engr., Field Section Engineer Office, Salt Lake City, Utah.	B. F. McLouth H. G. Richardson	*E. E. Tughy *N. Truax
Hall, Elmo, Owner, Empire Gas & Equipment Co., Denver, Colo.	L. R. O'Rear F. L. Adams	G. D. Maves D. J. McQuaid
Hamlet, Aylmer, Branch Office Mgr., C. A. Dunham Co., Ltd., Montreal, Que., Canada. *(Advancement)*	Leo Garneau R. F. Wormley	A. E. Watts J. B. Dykes
Harrison, William Z., Owner, Harrison & Co., Salt Lake City, Utah.	H. G. Richardson B. F. McLouth	*G. W. Williams *H. K. Beecher, Jr.
Hartsfield, Charles G., Field Refrig. Engr., Hq. 4th Service Command, Atlanta, Ga.	W. P. Sherman J. V. Poujade	L. F. Lawrence, Jr. W. J. McKinney
Henegar, Barnie V., Owner, Southland Supply Co., Dallas, Texas.	E. T. Gessell G. A. Linskie	J. A. Ray W. H. Moler
Henson, Wendell L., Htg. & Vtg. Engr., Hughes Heating Co., Memphis, Tenn.	T. J. O'Brien R. H. Hoshall	J. D. Flinn J. J. Nolan
Herman, Harry H., Owner, Harry H. Herman, Denver, Colo.	John McCabe G. D. Maves	F. L. Adams L. R. O'Rear
Heyse, Harold S., Asst. Mgr., Heyse Sheet Metal Works, Colorado Springs, Colo.	G. D. Maves *E. J. McEahern	J. H. McCabe F. L. Adams
Holford, Douglas B., Branch Mgr., Johnson Service Co., Salt Lake City, Utah.	H. G. Richardson B. F. McLouth	*G. W. Williams *H. K. Beecher, Jr.
Holmes, Oliver A., Jr., Mech. Engr., Hughes Heating Co., Memphis, Tenn.	T. J. O'Brien J. D. Flinn	J. J. Nolan W. E. Thorpe
Hook, Louis M., Engr. & Salesman, Rio Grande Fuel Co., Denver, Colo.	G. D. Maves J. H. McCabe	F. L. Adams L. R. O'Rear
Hughes, Charles, Civil Engr., Naval Air Station, Millington, Tenn.	T. J. O'Brien R. H. Hoshall	J. D. Flinn J. J. Nolan
Hughes, Ralph, Partner, Hughes Heating Co., Memphis, Tenn.	T. J. O'Brien R. H. Hoshall	J. D. Flinn J. J. Nolan
Hummel, David M., Mgr. of Engrg., Yale University Service Bureau, New Haven, Conn.	L. A. Teasdale T. J. Converse	L. E. Seeley H. J. Blakeley
Irvine, Leland K., Engr. & Mgr., Intermountain Insulation Co., Salt Lake City, Utah.	B. F. McLouth H. G. Richardson	*G. W. Williams *H. K. Beecher, Jr.
Jensen, Albert O., Owner, Wholesale Furnace & Supply Co., Omaha, Neb.	B. K. Eaton M. J. Olson	John Engskow B. G. Peterson
Jespersen, Soren J., Mech. Engr., Hq. 9th Service Command Engr., Salt Lake City, Utah.	B. F. McLouth H. G. Richardson	*E. E. Tughy *N. Truax
Johnson, Harry H., Owner, City Plumbing & Heating Co., Laramie, Wyo.	F. L. Adams L. R. O'Rear	G. D. Maves J. J. Johnson
Johnson, James J., Htg. & Vtg. Engr., American Radiator & Standard Sanitary Corp., Denver, Colo.	L. R. O'Rear D. J. McQuaid	F. L. Adams J. H. McCabe
Jones, T. Paul, Owner-Gen. Mgr., Air Equipment Co., Denver, Colo.	F. L. Adams H. H. Herman	G. D. Maves J. H. McCabe

Kaun, William F., Partner, W. F. Kaun & Son, Dallas, Texas.	H. J. Martyn W. A. Catlett	J. A. Ray M. L. Brown
Koubek, Joseph V., Engr., National Carbon Co., Cleveland, Ohio.	L. E. Slawson E. W. Gray	D. L. Taze W. M. Lowe
Kugeler, H. Coors, Application Engr., The Stearns Roger Manufacturing Co., Denver, Colo.	L. R. O'Rear D. J. McQuaid	F. L. Adams J. H. McCabe
Labadie, William, Supt., Estimating, Universal Plumbing & Heating Co., Toronto, Ont., Canada.	A. J. Strain Robert Kerr	V. J. Jenkinson W. H. Evans
Ladewig, Larry L., Htg. & Air Cond. Eng., Houston Natural Gas Corp., Houston, Texas.	F. C. Brandt A. F. Barnes	B. P. Fisher W. R. Etie
Lammons, John B., Htg. & Vtg. Sales, American Radiator & Standard Sanitary Manufacturing Co., Memphis, Tenn.	W. E. Thorpe J. D. Flinn	J. J. Nolan T. J. O'Brien
Larimer, William M., Mgr., Htg. Dept., Crane O'Fallon Co., Denver. Colo.	F. L. Adams J. E. McNevin	L. R. O'Rear G. D. Maves
Lewis, Daniel H., Owner, Lewis Engineering Service, Detroit, Mich.	R. H. Oberschulte R. D. Randall	T. H. Mabley L. A. Burch
Locke, C. F. A., Branch Mgr., Minneapolis-Honeywell Regulator Co., Indianapolis, Ind.	R. D. Tutt W. E. Goohs	E. T. Clucas R. I. Drum
Lym, Joseph H., Owner, Lym Engineering Co., Salt Lake City, Utah.	B. F. McLouth H. G. Richardson	*G. W. Williams *H. K. Beecher, Jr.
Malm, Edwin L., Bell & Gossett Co., Morton Grove, Ill.	E. M. Mittendorff E. J. Gossett	C. E. Pullum F. H. Gaylord
McCabe, John H., Rocky Mt. Sales Mgr., American Blower Corp., Denver, Colo.	E. L. Hogan O. G. Ward	Harvey McPhail L. R. O'Rear
McEahern, Edward J., Vice-Pres., William A. Flatt Co., Denver, Colo.	J. H. McCabe G. D. Maves	F. L. Adams L. R. O'Rear
McGrew, Joseph A., Sales Engr., American Radiator & Standard Sanitary Corp., Denver, Colo.	G. D. Maves F. L. Adams	J. J. Johnson J. H. McCabe
Michael, Robert K., Property Inspector, The Prudential Insurance Co. of America, Denver, Colo.	Carl Clegg F. L. Adams	F. F. Dodds L. R. O'Rear
Mohan, John F., Secy.-Treas., Fox Supply Co., Inc., Denver, Colo.	F. L. Adams D. J. McQuaid	L. R. O'Rear *R. W. Hanington
Mizener, Ralph S., Sales Engr., Parent & Kirkbride, Philadelphia, Pa.	J. O. Kirkbride H. M. Parent	R. S. Arnold R. F. Hunger
Munhall, J. Kenneth, Indus. Htg. Engr., Edwin L. Wiegand Co., Buffalo, N. Y.	W. J. Sommers S. W. Strouse	*W. P. Davis F. A. Moesel
Murdock, Charles E., Plant Mgr., The Stokermatic Co., Salt Lake City Utah.	B. F. McLouth H. G. Richardson	*G. W. Williams *H. K. Beecher, Jr.
Nelson, Walter L., Chief Mech. Engr., District Government, Washington, D. C.	Henry Norair W. D. Marshall	W. H. Littleford Glegge Thomas
Novak, Charles J., Dist. Fuel Rationing Officer, Office of Price Administration, Indianapolis, Ind.	I. W. Cotton W. C. Bevington	S. E. Fenstermaker C. H. Hagedon
Nussbaum, Otto J., Chief Engr., Kramer Trenton Co., Trenton, N. J.	William Goodman C. S. Leopold	*C. R. Logan *Israel Kramer
O'Neill, Joseph F., Mech. Engr., Trane Company of Canada, Ltd., Toronto, Ont., Canada.	J. P. Fitzsimons W. C. Kelly	A. S. Morgan D. O. Price
Payne, R. L., Owner, Air Flow Heating Co., Denver, Colo.	Frank L. Adams G. D. Maves	*R. H. Eroin J. H. McCabe
Perry, Lester L., Comm'l. Sales & Service Mgr., Frigidaire Div., General Motors Corp., Denver, Colo.	L. R. O'Rear G. D. Maves	F. L. Adams J. H. McCabe
Perry, M. Arthur, Supt. of Maintenance, DePauw University, Greencastle, Ind.	W. C. Bevington S. E. Fenstermaker	G. B. Supple J. H. Niesse
Pollard, Charles H., Mgr., C. H. Pollard Plumbing & Heating Co., Monte Vista, Colo.	G. D. Maves F. L. Adams	L. R. O'Rear J. J. Johnson
Rice, Percy L., Maintenance Engr., War Dept., Fitzsimmons General Hospital, Denver, Colo.	L. R. O'Rear D. J. McQuaid	G. D. Maves J. H. McCabe
Schulz, Walter F., Sr. Partner, Schulz & Norton, Memphis, Tenn.	J. D. Flinn J. J. Nolan	W. A. Danielson W. E. Thorpe
Seelbach, Herman, Jr., Dist. Mgr., Minneapolis-Honeywell Regulator Co., Buffalo, N. Y. *(Advancement)*	M. C. Beman B. C. Candee	L. P. Saunders S. M. Quackenbush
Shelley, Karl B., Asst. Engr., Wertz Engineering Co., Reading, Pa.	J. O. Kirkbride E. K. Wagner	H. M. Parent A. W. Luck
Simonds, Chauncey A., Owner, Grand Rapids, Mich.	W. W. Bradfield F. C. Warren	H. D. Bratt P. O. Wierenga
Singleton, John H., Vice-Pres. & Gen. Mgr., C. A. Crosta, Inc., Denver, Colo.	F. L. Adams H. H. Herman	G. D. Maves J. H. McCabe
Skinner, Frank, Supt., Barber Plumbing Co., Inc., Houston, Texas.	A. F. Barnes D. M. Mills	F. C. Brandt B. P. Fisher
Smith, Alexander S., Repr., Jenkins Bros., Denver, Colo.	Frank L. Adams D. J. McQuaid	L. R. O'Rear *R. W. Hanington
Smith, Edward D., Asst. Mgr., The Lang Co., Salt Lake City, Utah.	H. G. Richardson B. F. McLouth	*G. W. Williams *H. K. Beecher, Jr.
Smith, John A., John A. Smith Co., Denver, Colo.	L. R. O'Rear G. D. Maves	J. J. Johnson F. L. Adams
Smith, Karl H., Factory Repr., American Radiator & Standard Sanitary Corp., Denver, Colo.	F. F. Dodds Gustav Nottberg	Carl Clegg F. L. Adams
Smith, Vernon D., Draftsman, A. M. Kinney, Inc., Cincinnati, Ohio.	M. E. Mathewson G. V. Sutfin	H. L. Sproull* E. W. McNamee
Spencer, Charles H., Sales & Service Supvr., Stokermatic Co., Salt Lake City, Utah.	H. G. Richardson B. F. McLouth	*G. W. Williams *H. K. Beecher, Jr.
Trautman, Fred L., Owner, Trautman Engineering Co., Denver, Colo.	D. J. McQuaid F. L. Adams	G. D. Maves J. H. McCabe
Turner, George W., Sales Engr., Minneapolis-Honeywell Regulator Co., Cedar Rapids, Iowa.	T. R. Johnson D. E. Wells	A. L. Walters M. L. Todd
Updegraff, Lee, Owner, Franklin Engineering Co., Los Angeles, Calif. *(Reinstatement and Advancement)*	S. H. Downs Leo Hungerford	Maron Kennedy A. G. O'Rear
Vyff, Paul C., Research Engr., Battelle Memorial Institute, Columbus, Ohio.	*M. L. Carpenter *L. R. Baker	*Tore Franzen *P. H. Pretz
Ward, Cyril B., Supt., Gas Htg. Dept., Public Service Company of Colorado, Denver, Colo.	F. L. Adams J. E. McNevin	G. D. Maves J. H. McCabe
Waterman, Douglas R., Sales Engr., Hendrie & Bolthoff Manufacturing & Supply Co., Denver, Colo.	L. R. O'Rear D. J. McQuaid	F. L. Adams *R. W. Hanington
Watson, Charles E. W., Pres., John Watson & Co., Ltd., Westmount, Que., Canada.	T. H. Worthington Leo Garneau	F. Aylmer Hamlet R. F. Wormley
Wesby, Vernon L., General Foreman, Utilities Operating Div., General Motors Corp., LaGrange, Ill.	J. I. Philippi J. S. Kearney	J. E. McClellan O. G. Ward
Woehlke, Herman J., Estimator & Asst. Mgr., Bell Plumbing & Heating Co. Denver, Colo.	G. D. Maves J. H. McCabe	*E. J. McEahern F. L. Adams
Wright, Jack, Owner, Canadian Plumbing & Heating Specialties, Ltd., Montreal, Que., Canada.	T. H. Worthington A. M. Peart	Leo Garneau F. A. Hamlet

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*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Article B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

Alyea, Harold W., Design & Development Engr., Johnson Service Co., Milwaukee, Wis.
Arnold, Robert S., Owner, Robert Arnold Sales & Engineering Co., Wallingford, Pa. *(Advancement)*
Avera, Alvan F., Chief Engr., Dallas Air Conditioning Co., Dallas, Tex.
Baker, James, Partner, Ross & Greig Registered, Montreal, Que., Canada.
Belanger, William, Owner, Southeastern Supply Co., New Bedford, Mass.
Boucher, Kent D., Mgr., Carrier Div., United Clay Products Co., Washington, D. C.
Boyd, Lyle E., Air Conditioning Supvr., Caterpillar Military Engine Co., Decatur, Ill. *(Advancement)*
Buchanan, Walter P., New England Mgr., B. F. Sturtevant Co., Boston, Mass.
Cooper, Albert W., Branch Mgr., Johnson Service Co., Denver, Colo. *(Reinstatement)*
Davies, Edwin A., Dist. Repr., Hoffman Specialty Co., Indianapolis, Ind.
Davis, Clark M., Mech. Engr., Puget Sound Navy Yard, Bremerton, Wash.
Doing, L. J., Engr., U. S. Army Engineers, Denison, Tex.
Grosvold, F. E., Eau Claire, Wis. *(Reinstatement)*
Hauf, Joseph C., Jr., Engr., May Oil Burner Corp., Baltimore, Md.
Holbrook, Frank M., Engr., Alpha Steam Specialty Co., New York, N. Y. *(Reinstatement)*
Holt, Walter H., Fan & Blower Sect., General Industrial Equipment Div., War Production Board, Washington, D. C. *(Reinstatement and Advancement)*
Johnson, Raymond C., Dir. of the Lab., Anthracite Industries, Inc., Primos, Delaware Co., Pa.
Kane, John M., Supervising Engr., American Air Filter Co., Louisville, Ky.
Kuhn, William H., Partner, Payne & Kuhn, Dallas, Tex.
Ledbetter, Norvell C., Htg. Engr., N. O. Nelson Co., Memphis, Tenn.
Leitch, Kelvin D., Treas., The Arthur S. Leitch Co., Ltd., Toronto, Ont., Canada.
Lewis, Gelder V., Vice-Pres., John G. Lewis Plumbing & Heating Co., Kansas City, Mo.
Little, Raymond, Equitable Gas Co., Pittsburgh, Pa. *(Advancement)*
Lynde, C. J., Jr., Asst. Plant Engr., G. Lorne Wiggs & Co., Montreal, Que., Canada.
Martin, Harold L., Htg. & Vtg. Engr., Kaighin & Hughes, South Houston, Tex.
McCarl, Harry E., Utilities Engr., Des Moines Ordnance Plant, Des Moines, Iowa.
Meredith, John W., Htg. Engr., U. S. Navy, Boston Yard, Charlestown, Mass.
Miner, H. Harvey, Partner, Miner Supply Co., Red Bank, N. J. *(Advancement)*
Moe, Parker A., Chief Engr., International Harvester Co., Milwaukee, Wis.
Murray, William A., Pres., William A. Murray, Inc., Hartford, Conn.
Olson, Arthur A., Vice-Pres., Lee Engineering Co., Youngstown, Ohio.
Purinton, Dexter J., Asst. Plant Mgr., Wright Aeronautical Corp., Paterson, N. J. *(Advancement)*
Reinhardsen, Daniel, Dist. Sales Mgr., Spencer Heater Co., New York, N. Y.
Seippel, John H., Vice-Pres. & Gen. Mgr., Hoffman Specialty Co., Indianapolis, Ind. *(Reinstatement)*
Smith, Russell J., Mfrs'. Repr., Heating Equipment, St. Louis, Mo. *(Reinstatement and Advancement)*
Stewart, C. W., Ilg Electric Ventilating Co., New York, N. Y. *(Reinstatement)*
Stewart, Wesley O., Branch Mgr., Johnson Service Co., Los Angeles, Calif. *(Advancement)*
Storey, John H., Pres., John Tweddle, Ltd., Montreal, Que., Canada.
Taylor, Robert B., Repr., Buffalo Forge Co., Albany, N. Y. *(Advancement)*
Thompson, William D., Mgr., Indus. Div., Laclede Gas Light Co., St. Louis, Mo.
Uicker, John J., Prof. and Acting Dir., Mech. Engrg. Dept., University of Detroit, Detroit, Mich.
Ullrich, A. B., Jr., Sales Engr., Gilbert Engineering Co., Dallas, Tex. *(Advancement)*
Wieland, John J., Mech. Engr., Alto, Mich.
Wolters, Harold W., Mgr., Mechanical Draft Dept., Clarage Fan Co., Kalamazoo, Mich.
Woodward, Kenneth C., Htg. Engr., Chase Brass & Copper Co., Inc., Waterbury, Conn.
Yost, Claude, Mech. Engr., Zumwalt & Vinther, Dallas, Tex.

ASSOCIATES

Anderson, Harvey E., Secy., Narowetz Heating & Ventilating Co., Chicago, Ill.
Bain, Lawrence F., Outside Supt., Narowetz Heating & Ventilating Co., Chicago, Ill.
Band, Jack, Ottawa, Ont., Canada.
Beaghen, George W., American Blower Corp., New York, N .Y.
Blackwell, J. S., Prop., Air Engineering, Indianapolis, Ind.
Byerley, Francis A., 3rd, Bendix Prod. Div., Bendix Aviation Corp., South Bend, Ind.
Cambridge, W. A., Pres. & Gen. Mgr., Reid & Cambridge, Ltd., Westmount, Que., Canada.
Cameron, Joseph A., Jr., Mgr., New York Office, The Marley Co., Inc., New York, N. Y.
Christesen, Martin C., Field Engr., Hoffman Specialty Co., New York, N. Y.
Clark, Robert J. Plant Engr., Jack & Heintz, Inc., Bedford, Ohio.
Close, James W., Pres., Sheet-Metal Workers Union, Chicago, Ill.
Cox, LeRoy E., Almirall & Co., Inc., New York, N. Y.
Cronstrom, Kenneth A., Owner, Cronstrom Furnace & Sheet Metal Works, Minneapolis, Minn.
Denson, Walter, Jr., Vice-Pres., Walter Denson & Son, Inc., Jacksonville, Fla.
Director, Isador, Mech. Engr., Public Works, Navy Yard, Philadelphia, Pa.
Edmondson, John V., Asst. Mgr., Dallas Branch, Crane Co., Dallas, Tex.
Engskow, John C., Htg. Engr., Baker Manufacturing Co., Omaha, Nebr.
Farrell, George F., Htg. & Vtg. Engr., Lake City Ordnance Plant, Independence, Mo.
Gibbons, Michael J., Jr., Htg. Engr., M. J. Gibbons Supply Co., Dayton, Ohio.
Ginsberg, Maxwell R., Vice-Pres., Brunswick Appraisal Corp., Jamaica, N. Y.
Goodman, Carl L., Supt., of Utilities, Post Engineer, Camp Gruber, Okla.
Gratiot, Jules D., Sales Mgr., Air-Maze Corp., Cleveland, Ohio.
Hawk, Charles A., Jr., Mgr., Engineering Service Dept., A. M. Byers Co., Pittsburgh, Pa.
Heckert, Willard H., Htg. & Fuel Oil Div. Mgr., American Lubricants, Inc., Buffalo, N. Y.
Hubbell, Ned S., Plbg. & Htg. Engr., Mueller Brass Co., Port Huron, Mich.
Jessup, F. Judson, Jr., Htg. & Air Cond. Repr., Public Service Electric & Gas Co., Englewood, N. J.
Kingsland, George M., Zone Supvr., Minneapolis-Honeywell Regulator Co., Cleveland, Ohio.
Knight, Frank B., Plant Engr., Crosley Corp., Cincinnati, Ohio.
Lambert, Edward H., Mgr., Eastern Div., McQuay, Inc., Washington, D. C.
Lynch, Roderick O., Ventilation Engr., Dutton Asbestos & Supply Co., San Francisco, Calif.
Magarrell, Kenneth R., Mgr., Htg. Dept., Baker Manufacturing Co., Omaha, Nebr.
McPherson, Edwin R., Crosley Corp., Cincinnati, Ohio.
Molony, James J., Steam Engr., Nebraska Defense Corp., Mead, Nebr.
Montesano, Frank P., Mgr., The Frank A. McBride Co., Paterson, N. J.
Morin, Romeo P., Gibbs & Cox, Todd Hoboken Shipyard, Hoboken, N. J.
Orabella, Michael J., Pres., Ohio National Products, Inc., Cleveland, Ohio.
Paul, Dean W., Field Engr., Sterling Electric Motors, Inc., Los Angeles, Calif.
Phillips, Leonard S., Mgr., Commercial Relations, New York Steam Corp., New York, N. Y.
Porter, Hugh T., Vice-Pres., W. B. Connor Engineering Corp., New York, N. Y.
Randall, Gordon E., Supt., Randall & Co., Ltd., Winnipeg, Man., Canada.
Runge, Edwin A., Chief Engr., Lee Engineering Co., Youngstown, Ohio.
Smerling, Daniel, Dist. Sales Engr., Flynn & Emrich Co., New Haven, Conn.
Snyder, L. R., Owner, L. R. Snyder Co., Dallas, Tex.
Swart, Harvey G., Sales Engr., The Trane Co., Chicago, Ill.
Tolerton, H. A., Contracting Engr., Lee Engineering Co., Youngstown, Ohio.
Waldo, Harry J., Mfrs'. Repr., Water Cooling Equipment Corp., Air Devices Inc. & United States Register Co., New Orleans, La.
Watkinson, Gerald H., Jean Brilliant Co., Terre Bonne, Que., Canada.
Watterson, W. B., Adv. Mgr., Air-Maze Corp., Cleveland, Ohio.
Wierenga, P. O., Owner, Wierenga Brothers, Grand Rapids, Mich. *(Reinstatement)*
Yula, Ralph W., Chemical Engr., Lederle Laboratories, Inc., Pearl River, N. Y.

JUNIORS

Deverall, Charles R., Asst. Executive, Purdue University, West Lafayette, Ind.
Kavanagh, Perry E., Administrative Asst., Yale University, New Haven, Conn.
Malloy, William W., Service & Application Engr., Ilg Electric Ventilating Co., Philadelphia, Pa.
Smith, William E., Sr. Draftsman, Kodak Ltd., Wealdstone, Middlesex, England.

STUDENT

Kaufman, Aaron M., Student, Purdue University, West Lafayette, Ind.

Officers

sident......................................S. H. DOWNS
st Vice-President..........................C.-E. A. WINSLOW
cond Vice-President......................ALFRED J. OFFNER
asurer.......................................L. P. SAUNDERS
cretary.....................................A. V. HUTCHINSON
chnical Secretary.........................CARL H. FLINK

Council

H. DOWNS, *Chairman*   C.-E. A. WINSLOW, *Vice-Chairman*

Three Years: C. M. ASHLEY, L. T. AVERY, L. E. SEELEY, G. D. WINANS.

Two Years: J. F. COLLINS, JR., JAMES HOLT, E. N. MCDONNELL, H. URDAHL.

One Year: W. A. DANIELSON, L. G. MILLER, A. E. STACEY, JR., M. WOODS, M. F. BLANKIN, G. L. TUVE, *Ex-Officio.*

Council Committees

ecutive—A. J. Offner, *Chairman;* E. N. McDonnell, A. E. Stacey, Jr.

nance—B. M. Woods, *Chairman;* L. E. Seeley, T. H. Urdahl, L. P. Saunders, *Ex-Officio.*

embership—M. F. Blankin, *Chairman;* J. F. Collins, Jr., G. D. Winans.

etings—C.-E. A. Winslow, *Chairman;* L. T. Avery, L. G. Miller.

andards—L. P. Saunders, *Chairman;* C. M. Ashley, James Holt.

Advisory Council

F. Blankin, *Chairman;* Homer Addams, D. S. Boyden, W. H. Carrier, S. E. Dibble, W. H. Driscoll, E. O. Eastwood, W. L. Fleisher, H. P. Gant, F. E. Giesecke, E. Holt Gurney, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, John Howatt, W. T. Jones, D. D. Kimball, G. L. Larson, S. R. Lewis, Thornton Lewis, J. F. McIntire, F. B. Rowley and A. C. Willard.

Nominating Committee

CHAPTER	REPRESENTATIVE	ALTERNATE
Atlanta	T. T. Tucker	I. B. Kagey
Cincinnati	G. V. Sutfin	H. A. Pillen
Connecticut	H. E. Adams	Stanley Hart
Delta	J. S. Burke	C. B. Gamble
Golden Gate	R. A. Folsom	C. E. Bentley
Illinois	E. M. Mittendorff	A. O. May
Indiana	G. B. Supple	J. G. Hayes
Iowa	C. W. Helstrom	W. W. Stuart
Kansas City	D. M. Allen	W. A. Russell
Manitoba	F. L. Chester	William Glass
Massachusetts	E. G. Carrier	R. T. Kern
Michigan	S. S. Sanford	W. H. Old
Minnesota	R. C. Jordan	F. B. Rowley
Montreal	T. H. Worthington	A. B. Madden
Nebraska	D. E. McCulley	B. G. Peterson
New York	R. A. Wasson	C. S. Koehler
North Carolina	Arvin Page	P. L. Guest, Jr.
North Texas	G. A. Linskie	E. T. Gessell
Northern Ohio	L. S. Ries	John James
Oklahoma	E. T. P. Ellingson	
Ontario	V. J. Jenkinson	W. C. Kelly
Oregon	E. C. Willey	
Pacific Northwest	M. N. Musgrave	J. D. Sparks
Philadelphia	H. B. Hedges	Edwin Elliot
Pittsburgh	T. F. Rockwell	E. H. Riesmeyer, Jr.
St. Louis	G. B. Rodenheiser	C. F. Boester
South Texas	J. A. Walsh	A. B. Banowsky
Southern California	Leo Hungerford	W. O. Stewart
Washington, D. C.	F. A. Leser	W. H. Littleford
Western Michigan	C. H. Pesterfield	J. W. Miller
Western New York	S. M. Quackenbush	S. W. Strouse
Wisconsin	A. S. Krenz	M. W. Bishop

Officers of Local Chapters

Atlanta: Organized, 1937. Headquarters, Atlanta, Ga. Meets, First Monday. President, M. M. Crout, 412 Houston St., N. E. Secretary, L. L. Barnes, 3995 N. Stratford Rd.

Cincinnati: Organized, 1932. Headquarters, Cincinnati, O. Meets, Second Tuesday. Honorary President, Capt. C. E. Hust. President, G. V. Sutfin, 1005-6 American Bldg., Cincinnati 2. Secretary, A. W. Edwards, 3423 Paxton Ave., Cincinnati 8.

Connecticut: Organized, 1940. Headquarters, New Haven, Conn. President, L. A. Teasdale, 20 Ashmun St. Secretary, Winfield Roeder, 405 Temple St.

Delta: Organized, 1939. Headquarters, New Orleans, La. Meets, Second Tuesday. President, L. V. Cressy, 423 Baronne St., New Orleans 13. Secretary, J. S. Burke, 317 Baronne St., New Orleans 9.

Golden Gate: Organized, 1937. Headquarters, San Francisco, Calif. Meets, First Wednesday. President, C. L. Peterson, 2 Indian Rock Path, Berkeley. Secretary, James Gayner, 260 California St., San Francisco 11.

Illinois: Organized, 1906. Headquarters, Chicago, Ill. Meets, Second Monday. President, A. O. May, Room 925, 53 W. Jackson Blvd., Chicago 4. Secretary, C. M. Burnam, Jr., Room 1605, 6 N. Michigan Ave., Chicago 2.

Indiana: Organized, 1943. Headquarters, Indianapolis, Ind. Meets, Fourth Friday. President, W. C. Bevington, 730 Indiana Pythian Bldg. Secretary, C. W. Stewart, 1001 York St.

Iowa: Organized, 1940. Headquarters, Des Moines, Ia. Meets, Second Tuesday. President, C. W. Helstrom, 1614 Thompson. Secretary, B. E. Landes, 1603 47th St., Des Moines 10.

Kansas City: Organized, 1917. Headquarters, Kansas City, Mo. Meets, Last Monday. President, D. M. Allen, 215 Pershing Rd., Kansas City 8. Secretary, R. E. Bade, 1102 Commerce Bldg.

Manitoba: Organized, 1935. Headquarters, Winnipeg, Man. Meets, Third Thursday. President, Einar Anderson, 152 Bannerman Ave. Secretary, F. T. Ball, 810 9th Ave., W., Calgary, Alta.

Massachusetts: Organized, 1912. Headquarters, Boston, Mass. Meets, Third Tuesday. President, D. M. Archer, 143 Federal St., Boston 10. Secretary, C. W. Larson, 184 Sycamore St., Roslindale.

Michigan: Organized, 1916. Headquarters, Detroit, Mich. Meets, First Monday after 10th of month. President, W. H. Old, 1761 Forest Ave. W., Detroit 8. Secretary, A. E. Knibb, 1003 Maryland Ave., Detroit 30.

Minnesota: Organized, 1918. Headquarters, Minneapolis, Minn. Meets, First Monday. President, F. W. Legler, 17 W. 28th St. Secretary, F. H. Schernbeck, 1057 10th Ave. S. E.

Montreal: Organized, 1936. Headquarters, Montreal, Que. Meets Third Monday. President, A. M. Peart, 637 Craig, W. Secretary, Leo Garneau, Room 832, Dominion Square Bldg.

Nebraska: Organized, 1940. Headquarters, Omaha. Meets, Second Tuesday. President, G. E. Merwin, 5012 Parker St. Secretary, E. F. Adams, 1227 So. 52nd St.

New York: Organized, 1911. Headquarters, New York, N. Y. Meets, Third Monday. President, C. S. Koehler, 4374 Richardson Ave., New York 66. Secretary, Carl H. Flink, Room 3000, 51 Madison Ave., New York 10.

North Carolina: Organized, 1939. Headquarters, Durham, N. C. Meets, Quarterly. President, F. E. P. Klages, 1034 Jefferson Standard Bldg., Greensboro. Secretary, W. L. Hunken, 707 Guilford Bldg., Greensboro.

North Texas: Organized, 1938. Headquarters, Dallas, Tex. Meets, Third Monday. President, L. C. McClanahan, 603 Great National Life Bldg. Secretary, E. J. Stern, 701 Burt Bldg., Dallas 1.

Northern Ohio: Organized, 1916. Headquarters, Cleveland, O. Meets, Second Monday. President, D. L. Taze, 1302 Swetland Bldg., Cleveland 15. Secretary, R. H. Cutting, 3795 Glenwood Rd., Cleveland Heights.

Oklahoma: Organized, 1935. Headquarters, Oklahoma City, Okla. Meets, Second Monday. President, E. F. Dawson, University of Oklahoma, Norman. Secretary, E. T. P. Ellingson, 314 Savings Bldg., Oklahoma City 2. Acting Secretary, Earle W. Gray, Third and Harvey Sts.

Ontario: Organized, 1922. Headquarters, Toronto, Ont. Meets, First Monday. President, A. S. Morgan, 156 Glenmanor Dr. Secretary, H. R. Roth, 57 Bloor St., W.

Oregon: Organized, 1939. Headquarters, Portland, Ore. Meets, Thursday after First Tuesday. President, E. C. Willey, Oregon State College, Corvallis. Secretary, G. H. Risley, 516 S. W. Oak St., Portland 4.

Pacific Northwest: Organized, 1928. Headquarters, Seattle, Wash. Meets, Second Tuesday. President, M. N. Musgrave, 2019 Third Ave., Seattle 1. Secretary, J. D. Sparks, 7331 W. Green Lake Way, Seattle 3.

Philadelphia: Organized, 1916. Headquarters, Philadelphia, Pa. Meets, Second Thursday. President, A. C. Caldwell, 550 So. 48th St., Philadelphia 43. Secretary, J. O. Kirkbride, Fourth and Locust Sts., Philadelphia 6.

Pittsburgh: Organized. 1919. Headquarters, Pittsburgh, Pa. Meets, Second Monday. President, T. F. Rockwell, Carnegie Institute of Technology, Schenley Park. Secretary, E. H. Riesmeyer, Jr., 231-33 Water St., Pittsburgh 22.

St. Louis: Organized, 1918. Headquarters, St. Louis, Mo. Meets, First Tuesday. President, G. B. Rodenheiser, 4431 Finney Ave., St. Louis 13. Secretary, B. L. Evans, 571 Stratford Ave., University City.

South Texas: Organized, 1938. Headquarters, Houston, Texas. Meets, Third Friday. President, A. M. Chase, Jr., Box 359. Secretary, A. F. Barnes, 602 Kirby Bldg., Houston 2.

Southern California: Organized, 1930. Headquarters, Los Angeles, Calif. Meets, Second Wednesday. President, Leo Hungerford, 3485 Wonderview Pl., Los Angeles 28. Secretary, Arthur Theobald, 336 North Foothill Rd., Beverly Hills, Calif.

Washington, D. C.: Organized, 1935. Headquarters, Washington, D. C. Meets, Second Wednesday. President, J. W. Markert, 8506 Garfield St., Bethesda, Md. Secretary, A. S. Gates, Jr., 111 County Rd., Kensington, Md.

Western Michigan: Organized, 1931. Headquarters, Grand Rapids, Mich. Meets, Second Monday. President, C. H. Pesterfield, Michigan State College, East Lansing. Secretary, V. H. Hill, 2111 Colvin Court, Lansing 10.

Western New York: Organized. 1919. Headquarters, Buffalo, N. Y. Meets, Second Monday. President, S. W. Strouse, 493 Franklin St., Buffalo 2. Secretary, G. E. Adema, 39 W. Balcom St.

Wisconsin: Organized, 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, I. J. Haus, 3880 N. Richards St., Milwaukee 1. Secretary, M. W. Bishop, 231 W. Wisconsin Ave., Milwaukee 3.